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PERCEPTIONS OF TECHNOLOGICAL CHANGE:

The Attitude of Managers Towards

Group Technology in the United States

Food Equipment Industry

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ABSTRACT

In the center of today's continued and rapid technological change and ever competitive environment of the next millennium, manufacturers must realize that unless they are ready to consider and evaluate new technologies brought onto them, they may fail to adequately respond to the challenges that lie ahead of them.

This research was designed to determine the consistency of the perceptions of technical and non-technical administrators, in manufacturing environment, towards technological change and group technology as an advanced manufacturing system.

This research has included a review of literature with references to technological change, justification and implementation processes, and various manufacturing systems including group technology and its benefits.

This research has used the research method of empirical analysis (quantitative) and case studies (qualitative) to research perceptions of technical and non-technical administrators towards technological change and group technology.

Sixty-four (64) technical and fifty-one (51) non-technical administrators from fifty (50) manufacturing organizations in the United States of America responded to the mail survey questionnaire used in this research.

Responses were analyzed using the Repeated Measures ANOVA procedure to compare mean responses of each group. Two correlation analyses, Cronback Coefficient Alpha and Pearson Correlation Coefficient, were also performed to determine the reliability of the questionnaire as well as the degree of correlation of perceptions between these two groups.

This research, through the empirical analysis, has found that perceptions of the technical and non-technical administrators towards group technology were not consistent. In other words, they did not perceive the benefits of group technology in the same manner to the overall organizational performance. This finding was significant since it provided the first clear and comprehensive view of the technical and non-technical administrators' perception towards group technology and technological change, in Food Equipment Manufacturer Industry, in United States of America.

In addition, a number of cases were analyzed and the results have supported those of the quantitative analysis. Therefore, this research not only has provided basic data, which was unavailable prior to this investigation, but it also provided a basis for future studies.

Since the author of this research is an American citizen and is living in the United States, the American English language - including its punctuation and spelling - has been used throughout this research.

This research is dedicated to

God for his wisdom;

my parents where it all began; and

my wife, Kelly; my son, Shaheen; and my daughter, Sierra

for their support and understanding

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CHAPTER 1

INTRODUCTION TO THE THESIS

1.1 Introduction

"... Portfolio management is no way to conduct strategic management ...." according to Porter (1991, p. 26). Porter looks at a corporation as an assembly of product and market blends and pays very limited recognition to the internal processes that take place within firms, according to Drejer, Riis and Gertsen (1996). They also argue that the business view of strategy alone cannot rationalize the environment for acceptable competitive advantage.

According to Plossl (1991, p.1):

> "Manufacturing is out of control in most companies. The evidence is highly visible, showing clearly management's lack of ability to make valid plans and execute them properly. External, unavoidable factors destroy some companies, but the bulk of failures result from lack of understanding the manufacturing process and inability to take proper action."

Also according to Chambers (1990) manufacturing and business tactics should be formulated according to corporate and marketing objectives (integrating product characteristics and volume changes). In other words, these must be derived in accordance with the demand patterns. At the same time that the global output has increased, almost all manufacturing companies in the developed countries have experienced exceptional increases in competition for orders in recent years, which for some companies have had many consequences including reduced volume. This, in turn, has resulted in the need to reduce personnel and plants. Accordingly, and assuming that product range or the number of tasks has not been reduced, each employee of the plant has to be qualified to perform a wider range of tasks.

More frequent set-ups, due to diminishing order volumes, require reduced batch sizes that gradually become a higher proportion of total product cost and absorbed capacity. Shortening the order lead time, due to continuous market innovations, requires manufacturers to respond with shortened processing time. Customers increasingly place a greater demand on their suppliers for schedules with respect to both quantity and timing. Product proliferation and customization, due to customer and market demands, have equally led to a broadening of technical requisites, increased diversity and reduced volume. Shortening product life cycle, due to more tailored products and limited volumes, reduces the competitiveness of hard tooling and of devoted plants. Economics of policy pressures have given rise to reductions in inventory, and increasing numbers of customers require high levels of delivery reliability to aid their efforts in decreasing inventory.

According to Steudel and Desruelle (1992), the goal of any commercial manufacturing organization is to make a profit. Being a world-class manufacturing company simply means that the company can compete well, while making a profit, in an ever increasing global competitive environment at the present and in the future. As a result of the growing need for a decrease in response time to the customer, shortened product life cycles, and increase in global competition, it is critical that changes towards technologies such as group technology be investigated if further implementation and use of this or other advanced technologies are to be justified.

This research investigates the perceptions of technical administrators in areas such as engineering design, production, and manufacturing engineering. It also investigates the perceptions of non-technical administrators in such disciplines as sales, marketing, finance and accounting. This research particularly investigates the perceptions of these two groups of administrators, who are responsible for manufacturing performance and activities, in the food equipment and preparation industry in the United States of America. This investigation has reviewed in detail, with regard to group technology as an advanced manufacturing system:

(1) application and extent of use,

(2) justification,

(3) implementation, and

(4) benefits and limitations.

1.2 Purpose of Study

Dawson (1996) has shown that the management of technological change is dependent not only on the technology, but also on the way in which organizations, managers, and individual employees react to, and share, in the implementation of change. He explains that the choices, due to change, are prompted by the development of relationship and budget influence, and argues that the downfall of not integrating the people aspects of change with technical requirements would lead to a misalignment between the work organization and the culture on the shop floor.

Sohal, Samson and Weill (1991, P. 71) have stated that:

> "Planning for investment in advanced manufacturing technology (AMT) is one of the most difficult areas for manufacturing managers. A balancing of the need to create competitive advantage and the ability to fund the investment is required."

One of the proposals made by Sohal, Samson and Weill (1991) is that an analysis of future benefits over the long-term might mean that if an investment is not made, the old technology will lead to a decline in profitability.

Therefore this research was designed to determine the consistency of perceptions concerning group technology among technical and non-technical administrators who are responsible for manufacturing in the food equipment and preparation industry in the United States of America . It examines the following:

1. how and to what extent group technology is used;
2. reasons why some manufacturers use group technology while others do not;
3. applicability of group technology;
4. implementation strategies; and
5. benefits and disadvantages of group technology.

While problems such as inefficient line balance, machine breakdowns, poor quality, and absenteeism may impede efficiency, a vision of the ideal production flow throughout the factory must be created to effectively tie different disciplines together. According to Costanza (1990) successful manufacturing organizations must rely on three interdependent and crucial elements:

1. Business Strategy: This concept includes a total commitment from top management for customer responsive processes based on a flexible and total quality system. The manufacturing processes must be responsive to fluctuations in customer demand.
2. Common, Company-Wide Flow Technology: Flow manufacturing focuses on people in a different way than does traditional batch

production. It focuses on product cost, materials and overhead, while emphasizing employee involvement. This idea includes Total Quality Control (TQC) and Total Quality Management (TQM), engineering, process quality, operational cycle time, flexible material forecasting and flow process costing in a flow manufacturing process.

3. Total Employee Involvement: This idea emphasizes employee involvement to build a high-quality product using a continually improving process.

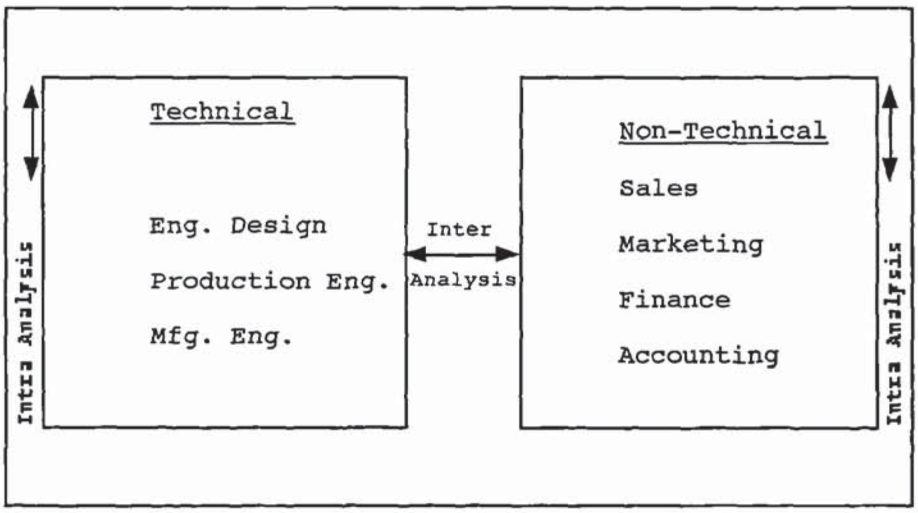
Consistent and positive perceptions among administrators could provide strong justification for increased support for technological change. The food equipment manufacturing industry was chosen because:

1. It incorporates sub-products from various other manufacturing industries, thus providing a good overview of a variety of industries;
2. It uses a variety of manufacturing and production systems, thus contributing to a better understanding of different production techniques; and
3. The researcher is an experienced engineering project manager within the industry.

Hill (1997) has asserted that the outcome of strategy has been forgotten. This is due to the implementation of strategy, which has failed to mesh functional viewpoints of markets and to consider and arrange for alternative directions. This has led to many organizations forming strategies at the corporate, business and functional levels, which are autonomous or separate of each other. He continues to emphasize that lacking a fundamental integration of position responsibilities and functions, the result is a collection of single strategies, without the necessary cohesion. In other words, where the individual functional strategies of an organization are not meshed, or collectively are not aligned with the corporate viewpoint, it will result in a fragmented outcome. Thus, there is a need for a cohesive strategy within the entire organization where it takes into consideration the individual needs, resulting in a more positive outcome.

In this research three comparisons are made (Figure 1.1). These include inter and intra-organization analysis. The research first compares technical and non-technical administrators' perceptions concerning the use of group technology. Second, the research analyzes perceptions among the technical administrators', and third the perceptions of non-technical administrators' regarding: (1) application and extent of use, (2) justification, (3) implementation, (4) benefits, and (5) disadvantages of group technology in the food equipment and preparation industry in the United States of America. Additionally, case study analysis was also employed to gain insight into perceptions and to contribute to a better understanding of the empirical results.

Figure 1.1
Group Technology Perception



1.3 Thesis Outline

Figure 1.2 briefly presents the outline of this thesis. Chapter 1 presents an introduction to the thesis, its purpose and limitations. Chapter 2 reviews the management of technological change and the influences of various implementation processes and justification.

A review of different manufacturing systems including the development of group technology, its benefits and limitations, is then presented in Chapter 3. A detailed research methodology is presented in Chapter 4. The empirical analysis, including data collection and findings, will be presented in Chapter 5. The qualitative analysis, the case studies, including data collection and findings are then presented in Chapter 6. Last, in Chapter 7, conclusions and recommendations for future studies are presented.

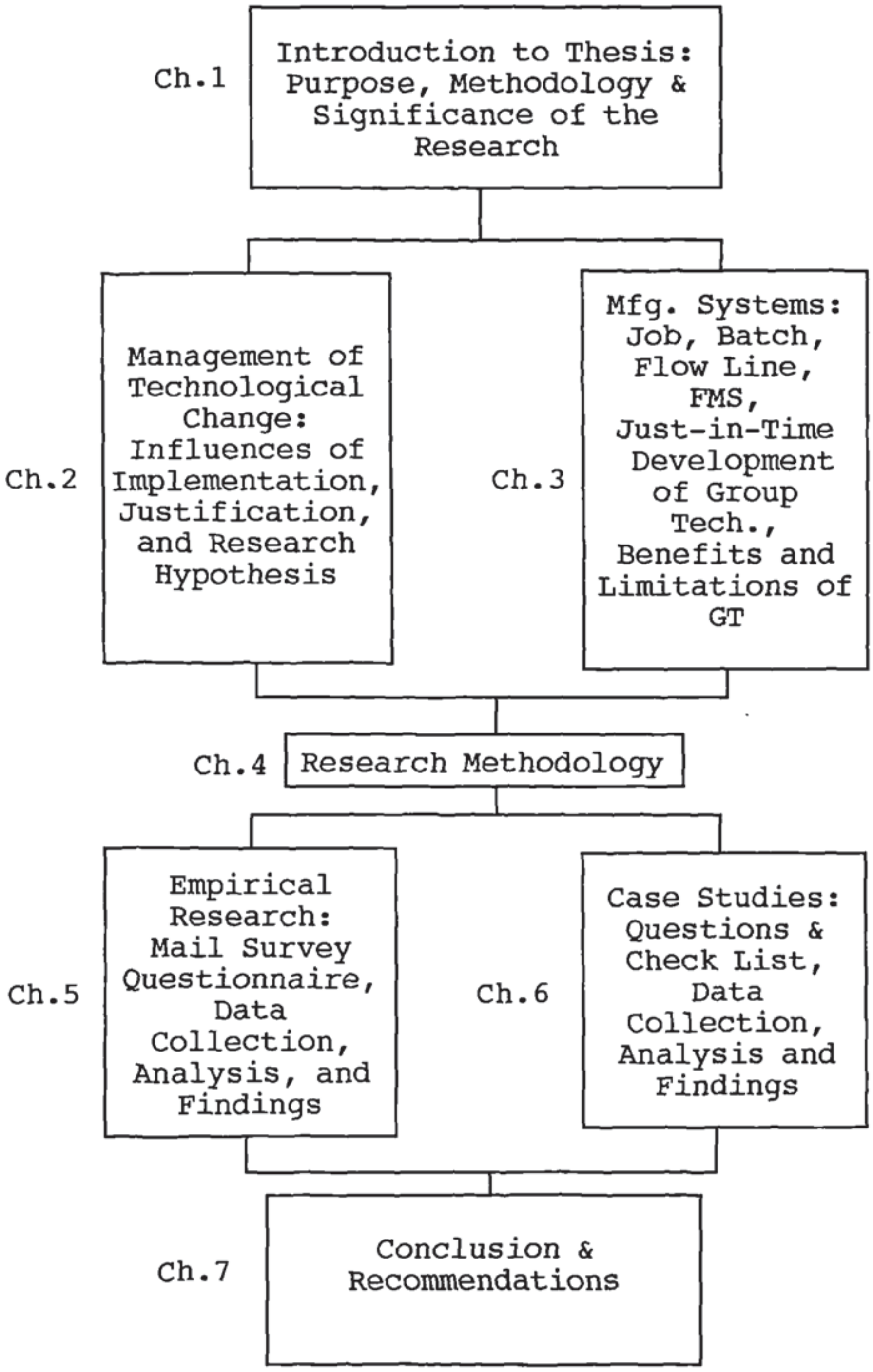
1.4 Methodology Outline

Several mail survey studies of group technology have been published. Examples are: Ham and Reed (1977), Levulis (1978), Burbidge (1979), Honda et al. (1980), and Hyer (1984 and 1989). However, they have all covered group technology application in general and did not consider the type of questions included in this research.

Therefore, a mail survey of two groups of participants was included in the research: (1) the technical administrators who were responsible for such activities as design, manufacturing, quality, and production/operations management, and (2) the non-technical administrators who were responsible for such activities as accounting, finance, marketing, and sales management.

In addition, selected case studies of various organizations, both within and outside the food equipment

Figure 1.2
Thesis Outline



industries, were completed to broaden the scope of this research and to better understand the underlying reasons for the consistencies (or inconsistencies) identified by analyzing the mail survey data.

1.5 Research Questions

Steudel and Desruelle (1992) argue that while many managers have some exposure to the fundamental ideas associated with different elements of today's manufacturing, most need a clear understanding of the basic concepts required to boost excellence in their organizations.

Pappas (1984) claims that technological considerations will develop the foundation for practically all decisions that management will make in the future. Nevertheless, he points out an area of concern:

> "... top management in the United States is not yet prepared to deal with the strategic implementation of technology. While senior management in many industries today may publicly embrace the importance of technology, they are frequently uncomfortable with it ...." (Pappas, 1984, p. 229)

According to Maychrzak (1988), Ettlie (1986), Jaikumar (1986), and Hwang and Salvendy (1985), companies are moving to manufacturing automation to meet competition, changing consumer trends, and to increase employees' productivity. They have invested in such technologies as Computer Aided Manufacturing (CAM), Flexible Manufacturing System (FMS) and Computer Numerical Controls (CNC) with the belief that they will reduce lead time, work-in-progress, inventory and more.

Based on this discussion, it would seem that the views of business managers and those responsible for the implementation of technology might be different. Thus, in this research, the question is whether there is any significant difference between the technical and the non-technical administrators' perceptions toward group technology as an advanced manufacturing techniques.

1.6 Limitations of the Study

The major limitations of this research include the following:

1. The population was chosen from food equipment and preparation manufacturing organizations in the United States and the conclusions are strictly applicable to that population only.
2. Two technical and two non-technical administrators were chosen from each organization, thus results are limited to that sample.

It should also be noted that minor limitations may exist due to certain assumptions having been made. These include:

1. The questionnaire was completed by the person to whom it was sent.
2. The individual completing the survey had adequate knowledge of his/her position in the organization.
3. The level of technology utilization was comparable at each organization in regards to Group Technology (GT), or other advanced manufacturing techniques.

1.7 The Food Equipment Industry

The food equipment industry is a multi-product one, and for some organizations, an international industry. The food equipment industry is the producer (manufacturer) and the distributor of food preparation equipment. It has facilities for providing design, manufacturing, financing, technological exchange and business planning on an international and domestic basis. In many cases each organization produces for both domestic and international markets. Although its' basic product dominates its' total activities, the industry also produces other lines of products in most of the countries in which it operates. These include such standard products as meat grinders (choppers), meat slicers, food processors, mixers, and various cooking equipment, among other items. Other products manufactured by some organizations include such items, or systems, as dishwashing equipment, point of sale equipment, scales, and different refrigeration products.

The food equipment industry is one which combines the principles of mechanical, electrical, industrial and human factors engineering to the design and manufacture of its products. In general, these products are produced from metals as well as nonmetallic materials such as plastics. The equipment also uses both mechanical systems (drives and transmissions) and electronic controls for its operations.

As with certain models of automobiles, home appliances or other products that are produced for specific markets, the food equipment industry also manufactures its numerous products in a single country or for a single market.

Appendix A provides an overview of the food equipment industry in the United States. It should be noted that although this data represents the majority of the organizations in this industry, they do not include some of the smaller ones. The data was collected from the individual Dunn & Bradstreet, "Competitors Reports" for each company (Dunn & Bradstreet, 1995 & 1996).

1.8 Significance of the Study

> "Most of the knowledge of actual implementation of cellular manufacturing comes from case studies of individual firms. Only a handful of studies have surveyed large groups of companies .... All studies covered group technology application in general and were not focused on cellular manufacturing." (Wemmerlov & Hyer, 1989, p.1512).

According to Burbidge & Dale, Dale and Dale & Willey (reported in Wemmerlov & Hyer, 1989), the most extensive studies on group technology explored data from a 35-company case history to establish regression patterns by which a company's future efficiency and effectiveness under group technology can be predicted. "Despite the abundance of past writings and the presently growing volume of cellular manufacturing literature, there exist a large number of critical issues that have yet to receive complete and satisfactory answers" (Wemmerlov and Hyer, 1987, p.414).

This research was significant, since it has provided the first coherent and clear view of the consistencies of administrators' perceptions of group technology.

The major purpose of this research was to identify areas of consistency so that future studies can be conducted into the areas that did not prove consistent. Since there is no data available at present, this research not only provided the first clear view of perceptions towards group technology, but also contributed a basis for other studies.

CHAPTER 2

MANUFACTURING CHANGE MANAGEMENT

2.1 Introduction

According to Drucker (cited in Prefontaine, Lefebvre, and Lefebvre, 1996) during the past several (post-capitalism) years, an explosion of technologies have brought new challenges and benefits to manufacturing organizations. To profit from these changes, when technologies are advancing rapidly and achieve effectiveness and efficiency, manufacturing requires a systematic method to plan, implement, and evaluate these benefits. The effective and successful development, execution, and administration of technology necessitates a multi-perspective, multi-disciplinary array of issues such as technology, people and financial constraints (Beard, 1996). Garvin (1993) notes that organizations need to have skills in systematic problem solving, experimentation with new approaches, learning from their own experiences as well as practices of others, transferring knowledge throughout the organization, and those that can have a profound impact most effectively, have a competitive advantage in the marketplace.

One approach to evaluation would be to determine the consistency of perceptions regarding certain variables. As noted in Chapter 1, reducing batch sizes, shortening the order lead time, and diminishing order volumes require manufacturers to respond with shortened processing time that could be achieved with group technology. However, in order to conduct the present investigation, several areas needed to be reviewed. This research could not be carried out unless the contextual environment of manufacturing and management of technological changes could be defined. Therefore, in this chapter, four major topics will be discussed that will provide a solid background for this research. These are: (1) Management of technological change, (2) Influences of implementation, (3) Justification processes, and (4) Benefits and limitations of group technology.

2.2 Management of Technological Change

A major responsibility in the area of manufacturing and production is the management of change. Among these responsibilities are the issues of: the effect of change on the cost, the product, the delivery, risks associated with the change, resources (human and financial or non-human) availability; and perhaps most importantly; is the change needed.

The Office of Capital Goods and International Construction Sector Group (1985) noted that one hard lesson learned in the early years of flexible manufacturing systems (FMS) is that success in being an innovator of technology is not the only prerequisite for capitalizing on its commercial value. The potential that exists for applications of new technology demand, such as FMS, has not resulted in the measures anticipated.

Analysis of change has relied on different frameworks according to Von Hippel (1977, 1982, and 1986). Schroeder (1990) maintains that changes in strategies are required since the adoption is influenced by factors such as competition and corporate objectives. There are other researches in this area that are widely cited (Mansfield, 1968, 1975, 1989, 1993-a and 1993-b; and Rogers and Shoemaker, 1971). Studies by Mansfield, for example, are based on a plan that the likelihood of a company instituting a new technology is related to that of firms currently or previously using that technology and the benefits of doing so. He has found that the rate of duplication tends to be faster for innovations that were more profitable and required somewhat smaller capital. In this regard, Rogers and Shoemaker (1971) offer a model of distribution that extends greater understanding into the complex phenomenon of technology distribution.

They suggest five factors of innovation that influence their rate of adoption. These are:

1. Relative advantages: This pertains to the degree in which an innovation is perceived as being better than *the idea it replaced, and is* positively related to *its rate of adoption.* Nevertheless, other *studies have shown that this* may not be the situation. *Instead of citing its* attributes, management often perceives the benefits (an example is FMS) to be lower cost and higher quality (Farley, Kahn, Lehman and Moore, 1987). Even though this is true to some extent, indirect benefits of FMS may include such areas as classification of product design within families of parts and the succeeding reduction of tool inventory (Office of Capital Goods and International Construction Sector Group, 1985).

2. Compatibility: This is the degree to which an innovation is perceived as compatible with existing values, experiences, and needs. However, attitudes towards the financial decision are often formed without taking into account the probable impact of the technology on the firm.

3. Complexity: This is the degree to which an innovation is perceived as somewhat difficult to understand and use, and is negatively related to its rate of adoption.

4. Trial ability: This is the ratio to which an

innovation has been tried or used on a limited basis. The perception of increased trial ability is positively related to an innovation's rate of adoption.

5. Observability: The final attribute of innovation described by Rogers and Shoemaker is the degree to which the results of an innovation are visible to others.

Even in companies committed to new technology however, innovation is not always seen as having strategic importance by senior decision makers. They regard new technology more as a technical project, and thus often not part of the corporate debate (Hill, 1985). The connection between technological change or innovation and company structure ís one that has been explored in relation to the management of organizational change (Carter and Williams, 1956 and Burns and Stalker 1961). However, more recent research has placed greater focus on the assumption that the dominant culture and attitudes within an organization may be as great a barrier to technological change as the organizational structure, especially when senior management sees new technology as a purely technical event (Ayers, 1984 and Dudley and Hassard, 1990).

Stinchcombe (1990) states that the fundamental problem with turning discovery into innovation is still not customary. Innovations usually bring about changes in the social system, and are likely to meet conflict of status within an organization.

According to Weill, Samson, and Sohal (1991), Advanced Manufacturing Technology (AMT) presents a new level of flexibility to firms with rigid work structures, and have found that there is a link between investment and strategy and an over-whelming reliance on normal investment criteria.

In their research, they concluded that many firms found it difficult to recruit staff skilled in the use of AMT. Adoption of technology requires fundamental changes in organizational structure and processes. According to Pavil (1990) it is not simply a process decision. It requires an integrated approach to organizational change across functions. Organizational learning, or a process of classifying and establishing required change (Argyris, 1994-a and Argyris 1994-b) is important in today's competitive environment and is one of the principles required for survival, according to Dodgson (1993).

While engineers may see integration as an objective in itself, especially when it is associated with the Total Quality Management (TQM), it is a thorough process in which everyone within the company shares the responsibility (DeCieri, Samson, and Sohal, 1991). For example, according to Forrester (1992), recent accounting graduates lacked the skills necessary to deal with complex circumstances and has suggested that they must also understand the economic, social, and cultural factors that affect organization.

An explicit statement of relative advantages, creating an open environment for learning, planning to learn from others, and to learn by doing can help to manage the adoption of new technology, according to Schroeder and Congden (1995).

2.3 Characteristics of World-Class Manufacturing

Satisfying the needs of global competition in manufacturing requires policies that generate value for the customers. The cost of energy, materials, labor and other resources continues to increase as customers no longer accept perpetually escalating prices. Obviously, the purpose of any commercial enterprise while enhancing the use of resources, manufacturing or not, is to make a profit (Steudel and Desruelle, 1992).

Many trends have altered the essence of the manufacturing environment. One of the major changes has been the increase of competition from foreign-made products in domestic markets. With the availability of a variety of products, consumers are asking for exceptional, creative products that are delivered to an accurate schedule. The tendency towards less product development and shorter life cycles is causing manufacturers to contemplate changes to their conventional techniques (McDaniel, 1992). Goldhard (1986) described the move to shorter life cycles as:

> "... we are seeing product life cycles shrinking to anywhere from one-half to one-third of their former length ...." (Goldhar, 1986, p.27).

Dean (1987) has also described the necessity for flexibility as:

> "... firms will need the ability to produce a wide variety of customized products simultaneously and to abandon production of current products in favor of new ones quickly. Firms must be able to manufacture a rapidly changing mix of high-quality, customized products at very low costs." (Dean, 1987, p. 6).

In this section, the coverage will be on managerial strategies of technology adoption. However, it would be advantageous to briefly describe the broader definition of strategy. Dilworth (1986, p. 50) defines strategy as "a long-term master plan of how the company will pursue its mission; it establishes the general direction in which the company will move."

Porter (1980), Mintzberg (1987), and Venkatraman and Prescott (1990) broadly formulate strategy as both a process and an outcome that institutes the building of an organization's goal, and the employment of action and the distribution of assets to attain those goals. Strategy, whether developed through the formal planning process or evolved through historical accident, need not be tied to rational planning and decision making.

Skinner (1985, p. 57) describes strategy as:

> "strategy is a set of plans and policies by which a company tries to gain advantages over its competitors. Generally, strategy includes plans for products and the marketing of the products to a particular set of customers."

Thurley and Wood (1983, p. 197) similarly described this as "a particular set of choices taken over a period of time for a given objective ... A 'strategy' therefore means a consistent approach over time which is intended to yield results in the medium and long term for specific problems."

Huff and Roger (1987), and Hart (1990) distinguish between the process of strategic management and the content of strategy. They define the content as being involved with the object of the strategic decision where the process of strategic management establishes the procedures that lead to tactics formulation.

Here, the indications are overwhelming that manufacturers must make changes in order to compete in the global markets. Manufacturing organizations must, according to McDaniel (1992):

1. recognize that change is required,
2. develop and implement a manufacturing direction, and
3. adopt new technology.

At the same time, strategy or management strategy, has been the subject of discussion in the literature for some time. Chandler (1982) has defined this strategy as:

> "The determination of the basic long-term goals and objectives of an enterprise and the adoption of courses of action and the allocation of resources necessary for carrying out those goals."

The question is, then, do managers have any set of proposals for new technology? Rothwell (1984) indicated that:

> "... lack of responsibility, resulting partly from organizational structures and functional roles: there was no clear-cut responsibility for devising and implementing organization-wide employment policies; line managers had responsibility only for their own department, while personnel managers may have had a wider remit but no power of implementation." (Rothwell, 1984, p.119).

Again, the purpose is stressed. Watson (1986) defined organizational strategy as:

> "... general direction in which the management of an organization 'pulls things together and along', in order to ensure long-term organizational survival."

The discussion can be broadened as was done by Whipp and Clark (1986) by way of their idea of 'strategic innovation'. They explained that this idea:

> "Refers to changes in technology and forms of work organization at all levels, which includes boards of directors or the various interfaces between a company and its suppliers or potential customers. Strategic innovation also embraces the technologies and forms of work organization adopted in the design and planning of an innovation and its execution, from the commissioning of new production facilities through to its operational form."

The significance of manufacturing strategy to the success of an organization has been substantially debated. Various papers have been published concentrating on manufacturing strategy since Skinner (1985) published his, "Manufacturing -- Missing Link in Corporate Strategy." Skinner argues (1974) the opportunity to effect some basic changes in the management of manufacturing, and identifies these as:

1. how manufacturers can compete,
2. how manufacturers can increase their efficiencies on the entire manufacturing organization and not just labor savings,
3. focus on technologies, and
4. organization of manufacturing policies so that the focus is on explicit tasks.

This strategy stresses the significance of technology to the organization and its benefits to business strategy. Maidique and Patch (1978) have differentiated between the technological and manufacturing strategies.

> "... While the two are closely intertwined elements of business strategy, they, nevertheless, address distinct sets of decisions." (Maidique and Patch, 1978, p. 237)

They continue on to explain that manufacturing strategy includes decisions considering location, scales and organization of productive assets, and is then prepared within the limits of technology. Technological strategy, on the other hand, includes alternatives between new technologies in which they are integrated into new products. Skinner (1986) identifies the wrong approaches taken by the management to improve productivity by pointing out that the management is mostly concerned with direct labor efficiency and the efficiency of the factory worker. More importantly, he claims that managers not only evaluate manufacturing as a non-strategic resource, but also neglect the provision of a coherent support for this strategy.

Pappas (1984) claims that technology considerations will develop the foundation for practically all decisions that management will make in the future. He nevertheless points out an area of concern:

> "... top management in the United States is not yet prepared to deal with the strategic implementation of technology. While senior management in many industries today may publicly embrace the importance of technology, they are frequently uncomfortable with it ...." (Pappas, 1984, p. 229)

According to Steudel and Desruelle (1992), many managers have some exposure to the fundamental ideas associated with different elements of today's manufacturing. However, most need a clear understanding of the basic concepts required to boost excellence in their organizations.

According to Maychrzak (1988), Ettlie (1986), Jaikumar (1986), and Hwang and Salvendy (1985), companies are moving to manufacturing automation to respond to competition, changing consumer trends, and to increase employees' productivity. They have invested in such technologies as Computer Aided Manufacturing (CAM), Flexible Manufacturing Systems (FMS) and Computer Numerical Controls (CNC) perceiving that they will reduce lead time, work-in-progress, and inventory.

Investing time in training complements the point made by Kropp (1990) that learning is an essential foundation for continuous improvement. He points out that many seem to worship technology, yet technology alone does not assure success. He goes on to justify the need for a new breed of educated managers who are broadly based. Once understood, the next step in developing the strategic plan is to determine strengths and weaknesses. Since no company can dominate in every area, the strategic plan must focus on the competitive strategies that will result in success.

The next step needs to address where and how to start. Since there are many different approaches available, the one that is best for an organization depends on the assessment of their competitive strengths and weaknesses.

The last and perhaps most important step is to integrate the vision, implementation and benefits to the organization. Many companies do poorly in this area and are unable to answer the basic question of "what is in it for me?" It is the responsibility of management to integrate these advantages in its vision for the organization.

The control of focused projects is the next step that the plan must address. It should identify ways to detail and use measures of performance that pertain to the goals of the project. The barriers of policies, practices and systems already in place in an organization to implementation are the most difficult tasks to overcome, demanding significant commitment from management.

Sustaining momentum is another issue that the plan needs to address. Only the desire to be the best can provide the fuel to maintain the momentum, as shown in Table 2.1. Skinner (1978) remarks that as competition widens, U.S. companies are finding the "going rough", struggling with internal problems, such as new technology, and shortages of skilled workers in achieving better productivity. He asserts that:

> "Technology, competition, and social change have brought serious problems for manufacturing. Further techno - logical and social changes will take place and, in combination with the natural competitive processes, will, I believe, continue to force an accelerating evolution in the factory. ... The corporations and managers that lead in bringing about changes in manufacturing management will gain an important competitive advantage." (Skinner 1978, p. 21)

Table 2.1
Seven elements of a strategic plan for world-class competitiveness

Elements	Options for implementation
1. Define objectives for WCM and corporate vision for excellence	- Management training on WCM
2. Assess existing enterprise strength and weaknesses for competitive advantages	- With diagnostic tools - By outside professionals - Bench marking, customer survey
3. Define approach (Choose projects & areas) - How to get started - What to do next	- Pilot project - Most beneficial steps - Two-front attack
4. Define strategies for communicating to employee: - Vision articulation - Implementation plan - Benefits to be expected	- Counsel from outside professional - Define win-win plans - Top management involvement
5. Define how to control focused projects (Progress measurements)	- Project leader (Champion) - Project management techniques
6. Define how to foster implementation and how to affect change GOAL: Entire work force support	- Management involvement - Employee education
7. Define how to sustain momentum and continue the evolutionary process	- Strong initial momentum - Employee involvement - Continuous improvement

From Manufacturing in the Nineties, How to become a mean, lean, world-class competitor by Steudel, H. J. and Desruelle, P. (1992), p. 17. Copyright by Van Nostrand Reinhold, 1992.

To become a viable competitor, a company must develop its vision in all areas, including development, design, manufacturing, marketing, and management. This can be gained only as a result of a team effort that includes management, union leadership, and the people in the work force.

Figure 2.1 illustrates how work force education and employee involvement are the building-blocks of a strategy to become a world-class competitor. The diagram illustrates that education and training are prerequisites to involving the employees in work teams whose mission is to:

1. analyze existing problems,
2. propose alternative solutions to management,
3. be actively involved in the implementation of the solution adopted by management, and as a result
4. participate in continuous improvement, that is one of the conditions for being a world-class competitor in the nineties.

The first element the strategic plan must address is how to envision world-class manufacturing in terms of what it is and how to apply it to achieve a competitive advantage. This involves defining the fundamental purpose and boundaries of the company and establishing a mission statement that reflects the corporate vision of excellence. Experience has shown that manufacturing excellence cannot be implemented by manufacturing managers alone. The corporate strategy for achieving world-class competitiveness (Steudel and Desruelle, 1992) must be supported by complementary financial, operational, and marketing plans that provide detailed steps covering how the corporate objectives and goals will be accomplished as shown in Figure 2.2.

Figure 2.1

The role of employee involvement in the strategy to becoming a world-class competitor

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From Manufacturing in the Nineties,
How to Become a Mean, Lean, World-Class Competitor
by Steudel, H. J. and Desruelle, P. (1992), p. 27.
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Figure 2.2

Corporate Strategy for Competitiveness

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From Manufacturing in the Nineties,
How to Become a Mean, Lean, World-Class Competitor
by Steudel, H. J. and Desruelle, P. (1992),
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Other research (Steudel and Desruelle, 1992) has identified twenty (20) elements as important for being a successful manufacturing organization. These are broadly divided into three groups of (Table 2.2):

1. management and employee involvement,
2. Quality, and
3. Production operation.

Table 2.2

Summary of the twenty characteristics of world-class manufacturing companies

Management/employee involvement
1. Visionary leadership and champion
2. New culture goals and thinking
3. Long-term strategic plan and direction
4. Employee involvement and human resource development
5. Integrative and holistic objectives
6. Goal-consistent measurement/reward systems
7. Product or customer focused organizations
8. Good communication systems and practices
9. Promotion/support of research and education

Quality
10. Customer-driven product development and marketing
11. Cross-functional teams for product design and manufacturing
12. Individual responsibility and continuous quality improvements
13. Statistical process control of key product characteristics
14. Emphasis on innovation and experimentation
15. Partnership-like relationship with quality - certified vendors

Production operation
16. Continuous-flow processing/cellular manufacturing
17. Demand-based, not capacity-based, processing
18. Quick changeover procedures/small lot sizes
19. Emphasis on standardizing/simplifying before automating
20. Preventive/predictive maintenance programs

From Manufacturing in the Nineties, How to Become a Mean, Lean, World-Class Competitor, by Steudel, H. J. and Desruelle, P. (1992) p. 10. Copyright by Van Nostrand Reinhold, 1992

According to Gillespie (1983) budgeting and planning for the use of technology is essential, especially due to the high cost of new technology. As a result, it is pivotal to review the practices used by many organizations to plan and budget for technology in support of the company's accomplishment. Once the issue of management of technological change and factors affecting manufacturing excellence is understood, then the process of implementation must be evaluated. This implementation process is reviewed in the next section.

2.4 Implementation Processes

Clearly, change will occur due to a number of reasons, including delivery to, and demand from the market. However, even when the need for change is identified, and properly documented, problems in actual implementation still may exist. These can generally be grouped into: top management support, anticipated problems, and whether to use a pilot program or gradual implementation.

Managing a company today poses challenges as never before. It is a challenge that companies have to accept if they are to survive and grow. Today, managers of manufacturing organizations face a more challenging, demanding, and complex situation than ever before. This is especially important when relating the many individual functions to the achievement of objectives (Geralle & Stark, 1988).

> "The function of management which encompasses the hardest tasks in group technology is the personnel function. As with any major innovation, the real problem with group technology is to persuade people, at all levels, to accept the change. In comparison, the material flow and technological problems are relatively simple." (Burbidge, 1975, p. 232).

What Burbidge has proposed is that successful implementation of technology will require a clear understanding of the needs and commitment by all personnel internal to the organization. This includes justification of resources required, adequate training at all levels, and understanding of the effects of implementation. However, this does not exclude external forces where suppliers of raw materials, for example, may be affected by implementation of a new technology or process, economical factors and competition. In discussing technology change and implementation, the relevance between the manufacturing and business strategies is an important element. In other words, how the introduction of new technology will impact the operations within the organization can be significant. While economists (Lillard and Tan, 1996; Mincer, 1989; Allen, 1992; Krueger, 1993; and Berman, Bound, and Griliches, 1994) have long been interested in the impact of technological change, it alone may not be the only reason for productivity increase. Productivity increase is one reason for technology adoption and it is not for every organization. For example, reduced time to market to meet the demands of customers, reduced operational cost, increase flexibility in production of different features and others are important reasons for adoption of new technology. It can be argued that technological change is the result of internal and external factors and it also follows an organization's profile of technical competencies. Although the process of change is generally an uneasy one, it could become more complicated and overwhelming when combined with technology. Nonetheless, whether an organization approaches the transition to technology change gradually or in one giant step, there are factors that requires detailed attention:

1. What are the fundamental capabilities that are needed for integration? These include, among others, human and capital resources, technology expertise, and perceptions that are needed for effective integration. Perception of technical and non-technical administrators in regards to benefits of group technology is studied in this research.
2. How do management and employees assess the need for change and its potential benefits? This is of most importance in technology change and adoption, where both resources (human, capital, and technology) and outcome (time to market, quality improvement, and cost to customers) need to be assessed in full detail. How technical and non-technical administrators perceive the benefits of group technology is studied in this research.
3. Once relevant skills have been developed, how would the change be managed? This mainly refers to human skills and expertise and whether they are available internally and could be obtained externally. Some of the important tasks in this area include cultural change, management commitment, planning and training. Again, how technical and non-technical administrators perceive the benefits of group technology is studied in this research.
4. What are some of the effective strategies that will facilitate the incorporation of change? For some organizations, increased profit and reduced labor costs are important

strategies. For others, increased market share or perhaps sustaining market share is critical. In managing change, resources assessment and training become essential and how technical and non-technical administrators perceive the benefits of group technology is studied in this research.

Implementation of a new production technology for a specific firm is not just a technical question that is based on elements such as the type of parts produced. What is important is that it hinges on the organization's readiness for change and the actions taken by the firm during implementation (Ettlie 1984 and Gerwin 1981).

> "The implementation of group technology never only means the analysis of component data and a reorganization of the plant layout but also inevitably involves changes to the way people work and sometimes in management structure. The extent of these changes range from minor readjustments of labor and first-line supervision at the shop-floor up to full-scale radical restructuring in the level of 'technology' used." (Gallagher and Knight, 1986, p. 60).

In a survey study of twenty (20) U.S. manufacturers, using group technology to detect the obstacles they had confronted during the implementation process, Hyer and Wemmerlov (1984) found three major problems in the implementation of group technology process. These included:

1. the organizational changes and human resistance,
2. classification and coding, and
3. planning and execution.

Many executives assume that simply the advantages of new technology combined with strategic significance will produce acceptance (Leonard-Barton and Kraus, 1985).

However, according to Burbidge (1975), jurisdiction and control of the implementation process should conceptually be in the hands of the top management. Burbidge suggests that the best results are achieved with a full-time assistant who will delegate many of the tasks to the managers to make changes and run the new system. The most important task of upper management is to maintain good labor relations.

It has been debated that installation of a new technology can be separated into five (5) stages (Bennett, 1986):

1. Acquiring acceptance of the change by departmental supervisors,
2. Obtaining approval of the change by the management,
3. Winning acceptance of the change by the employees involved and their representatives including the trade representatives,
4. Training employees to operate the new system, and
5. Providing for close contact with the development of the implementation until assured that the new system is operating as planned.

Figure 2.3 identifies some of the key parameters for successful implementation.

As with any major innovation the introduction of group technology may cause undesirable conditions. These however, could be avoided by careful planning and adequate training of all personnel in the organization (Burbidge, 1975). In 1976 the management of Otis advised its organization that the company would implement group technology as a means to help lighten the back-log and to recuperate the delivery

Figure 2.3
Key Parameters for Implementation

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Illustration removed for copyright restrictions

From Market Focused Production System: Design and Implementation,
P. 332, by Bennett, D. J. and Forester, P. L. (1993).
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schedules (Oliver, 1986). During the first phase of implementation, it was concluded not to move any machine tools. The equipment chosen for the manufacturing cell would stay at its present location and with its current supervision. Although the cells functioned with machines at their original locations, it was decided later to allocate space so that equipment could be moved into cell areas to improve operations.

A similar successful approach, according to Gallagher and Knight (1986), is to create an implementation or cross-functional team. The team members are from departments such as production, planning, control, design and engineering. If the team is to succeed, it needs meaningful support from the upper management. Such support can be best obtained by evaluating it at an adequately high level as illustrated in Figure 2.4.

Technological change, especially implementation of group technology, is not always an easy idea to accept. Many batch manufacturers may claim that their parts are always different and that they can not be reasonably grouped into families.

> "The only safe way to implement an innovation of this type is to divide it into a series of independent projects, each of which is capable of standing on its own. These projects are then tackled separately in a carefully planned sequence.....Before starting to plan, the planner must have a clear idea of the strategy, or policy, he intends to follow." (Burbidge, 1975, p.248)

Figure 2.4
The Ranking of the Implementation Team

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From Group Technology Production Methods in Manufacture (p. 54)
by C. C. Gallagher and W. A. Knight, 1986, Ellis Horwood Ltd.
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Burbidge (1975) states that, when implementing group technology, there are two policy decisions to be made: (1) the horizontal or vertical introduction, and (2) the general sequence of project introduction.

In the horizontal approach a model group, or cell, with its supporting functions is fully planned and installed. Additional groups are planned and installed only after successful implementation and evaluation of this first group. This is accomplished before a total installation in the horizontal approach. With the vertical approach, each system change is dealt with as a project and is then installed as a whole. Each project or system is implemented typically on a company wide basis. The second approach, the general sequence approach, is interested in the different objectives and tasks that must be executed and are required for full development and implementation of group technology.

Gallagher and Knight (1986) also offer a plan similar to that stated by Burbidge (1975) in that there are two approaches to implementation. First, through a factory in one sweep, and second, by a more gradual implementation.

Shafer and Rogers (1991) also have identified three general modes of implementation:

1. An informal approach: in this mode, manufacturing activities depend on component families in order to decrease set-up time;
2. A machine dedication approach: here component families are first established; however, none of the equipment is moved; and
3. A cell approach: this approach is similar to the machine dedication approach, except that it includes the relocation of equipment and machinery to create cells.

In an examination of users, Wemmerlov and Hyer (1989) found that forty-three percent of the respondents used a machine dedication approach, about fifty percent applied machine and cell approaches and the remainder used the cell approach.

Guarino and Wilemon (1990) similarly suggest that the selection, evaluation, and implementation processes for advanced technology should consider possible implementation issues as part of the justification process. They propose three approaches to the implementation of group technology:

1. A leadership approach: this is used for specific managerial skills to sustain existing functions by planning for expertise;
2. Construction of a more human work system: two theories, human factors and human relations constitute this perception:
    A) human factors: human factors attempts to match job aspects which may change when new technology is adopted;
    B) human relations: in contrast to human factors, human relations is involved with people in groups, and management's task is to create a favorable climate. This is believed to enhance performance in implementing new technology; and
3. An exchange approach: the implementation of new technology may be that we consider technology implementation success as a function of negotiating outcomes.

Lucas (1982, p. 387) stresses the long-term nature of implementation by saying:

> "... it is part of a process that begins with the very first idea for a system and the changes it will bring. Implementation terminates when the system has been successfully integrated with the operations of the organization."

Implementing group technology and cellular manufacturing does not involve changes which are merely of interest and concern to design, engineering, or manufacturing. The physical change of the layout and the grouping of parts to families affects the work for individuals in particular department(s) as well as for personnel in supporting groups such as quality assurance, maintenance, manufacturing and industrial engineering, design, production planning and control, accounting, and purchasing and sales. Implementation or adoption of group technology and cellular manufacturing will certainly have an impact on the entire organization (Wemmerlov and Hyer 1987).

Another important factor in implementation is resistance to change. This has always been difficult and is a universal human factor. It may take many forms, ranging from an individuals' status, understanding of the change and the need for change and willingness to adapt to the new environment.

> "There is no fully satisfactory theory of innovation implementation. The primary implication for managers is to prepare for a learning experience." (Guarino and Wilemon, 1990).

As suggested by Gallagher and Knight (1986), perhaps one successful approach to implementation is the establishment of a special interdisciplinary task force that reports directly to senior management. The task force should consist of highly experienced design, manufacturing, and data processing specialists. Management's special responsibility is to understand and coordinate the implementation process by maintaining good relations with members at all levels, including all unions. The secret of success in the introduction and implementation of group technology is to break it down into a number of independent small projects that can be completed individually.

Training should first focus on individuals who will be given responsibility and those who will be affected in the new organization. Additionally, to make the principles of group technology work in each division of the company, senior management must have the commitment of each department head. This commitment is usually obtained by senior management who should be knowledgeable of the fundamentals, all changes required, and the benefits of group technology and cellular manufacturing systems.

A detailed plan for implementation may still be weakened due to a specific environment in which it is being executed. Perhaps two of the most common issues with implementation are derived from organizational and individual resistance. Resistance from individuals can be answered in many ways, including training, depending on the particular situation. However, it is equally important that organizations learn from their past experiences in order to improve the process of implementation (Bennett, 1986).

Part of any technology implementation is a thorough evaluation of its advantages and required investment. Stated differently, a rearrangement or reorganization of the current system may in fact be even more effective than adoption of new technology (new technology does not guarantee more productive or efficient outcome). Manufacturing has been defined as the application of materials and equipment to produce products. However, management and other resources, such as people, are important in implementation of a new technology and it can be seen as broader aspects of management of manufacturing and production. The more clearly the need for adoption of new technology is identified, the more of an opportunity production becomes. Each system of manufacturing and production makes its' own premises on management role, in all areas and all levels, in justification and implementation. It is clear that each system of production requires a different set of management expertise and technical skill, but it is not necessarily more effective or efficient than other systems. Unless management realizes the particulars of each system, it can not truly make appropriate decisions on its' applicability or adoption. Such information is principally important today when many organizations are moving from one system of production into another. Moreover, if adoption of a new technology or technique is purely considered a mean of mechanics, the organization will gain ultimately the difficulties of the new system. After all, to achieve the benefits of any new system management must recognize that the new system involves new ideas, and must know what these are. For example, robotics and automation, for many business managers, is a mean for labor cost reduction and will consider return on investment as the basis for evaluation. What they may not recognize is the need for support of this automation such as training, production down time, programming, quality improvement, and others. Management, in today's competitive and global marketplace, must satisfy the demands of the system it ought to have, rather than those of the system it actually uses. Being unqualified or reluctant to apply what would be the most appropriate system results only in lack of performance. The next section reviews the process of justification.

2.5 Justification Processes

The extensive diversity of potential consolidation of resources in most of today's manufacturing organizations brings the challenge of how to choose the best combination of resources, and how to determine the capability of their operation. More importantly, the predominant role of marketing and financial specialists have contributed to the encouragement of inadequate commitments to seeking major advances in production efficiency in many industries. This has threatened the continued competitiveness of our industries (Gold, 1990).

> "The key reason for this is that the failure to recognize that basic technologies are built not only into the production machinery, but also into:
>
> 1. the expertise of the technical personnel,
> 2. the structure and operation of the production system,
> 3. the economically feasible range of changes in product mix,
> 4. the skills and organization of labor, and
> 5. even the very criteria used to evaluate new capital proposals."
>
> (Gold, 1990, p.7).

Once new technology is considered by a manufacturing organization, the justification assessment has two phases, which according to Boaden (1989) are:

1. resolution of whether the concept is worthwhile, and
2. analysis of whether a particular set of equipment should be chosen.

Concept justification is mainly strategic in nature that also involves financial matters. On the other hand, equipment justification is generally economic and must include strategic considerations (Gerwin and Kolodny, 1992).

A key point identifying proper strategies for effectiveness in group technology is the use of families of parts. As such, two important issues should be considered:

1. can design and shapes of parts or components be grouped in families?, or
2. can processing and tooling of parts or components be grouped in families?

Economic justification of group technology, and in general, advanced manufacturing technologies, has proved to be an extremely difficult task. The questions involved in rationalization or justification are not entirely unique to group technology and cellular manufacturing. Besides the economical advantages, group technology is also desirable from the human point of view. Through job enlargement, closer association with the product, and reduction in coordination needs, group technology can provide higher job satisfaction and more favorable labor relations (Burbidge, 1975).

A recent study of the Australian manufacturing industries by Singh and Sohal (1996) has identified that the most common justification technique used was return on investment. However, Chen and Small (1994) have emphasized that return on investment is not the best method, and that the justification process should consider both costs and non-financial factors. Noori (1990) has also suggested that justification should be based on strategic arguments rather than financial gains only.

A number of other benefits result from the allocation of a direct cost saving. For example, reduced throughput time and ability to meet deliveries could result in less pressure on personnel. This will enable the production personnel to focus on production activities. In addition, better delivery performance may result in an increase in sales. (Gallagher and Knight, 1986).

According to Shafer and Rogers (1991), the major objectives for adopting group technology and cellular manufacturing systems are to:

1. reduce set-up time: the benefits of reduced set up time includes the increase in production capacity, smaller lot sizes, less work in process, and shorter lead times. This in turn will result in more competitive advantages due to shorter lead times, more accurate forecasts and a chance to improve processes and quality;
2. produce parts cell complete: this results in shop floor control simplification and a potential to increase workers' accountability and responsibility. This may lead to increased job satisfaction and improved quality. It also results in a need for less labor and equipment to move products;
3. minimize investment in new equipment and maintain acceptable utilization levels: this will provide for more funds availability for R & D, improved financial performance and less downtime due to overloading equipment.

It is important, however, that economic justifications and implementation strategies be vigorously linked together for the technology justification processes. One significant area related to the justification of cellular manufacturing systems involves the recognition of cost and benefits sources, as well as the evaluation of cost and benefit levels (Wemmerlov and Hyer 1987).

The use and merits of group technology and cellular systems in manufacturing have been tested since its popularity in the 1960's, and then in the 1980's. It has been asserted that group technology has led to improvements in organizational effectiveness both with quality and lead time (Dale and Willey, 1977; Hyer, 1984 and Wemmerlov, 1988). Improved efficiency in terms of material handling, productivity, and inventory control have also been reported (Jackson, 1980 and Ransom, 1972).

Meredith and Suresh (1986) have proposed a method to equate the rationalization procedure with the intended use of a particular technology. Advanced manufacturing technologies span the spectrum from stand-alone equipment to fully automated systems. The level of integration and the synergistic impacts increase as analysis moves from stand-alone technology to computer integrated manufacturing. This is illustrated in Figure 2.5. Meredith and Suresh have also proposed three separate justification approaches to match the categories of manufacturing technology. Figure 2.6 introduces the justification methods, which are economic, analytic, and strategic.

The traditional economic justification techniques, such as payback, return on investment, internal rate of return, and net present value are mostly suitable for stand-alone systems. The analytical justification techniques are more complex than the economic approaches. However, they tend to be more realistic and capture uncertainties. The strategic approaches tend to be less quantitative than the other two techniques and typically involve subjective estimates of key indicators or surrogate measures related to strategic objectives.

On the basis of an isolated financial analysis, advanced manufacturing technology can often be successfully justified; however, its potential is never achieved. Managers confuse it with automation; they observe its fundamental benefits as direct labor savings, and organized labor sees it as a threat to job security (Primrose and Leonard, 1986-a and -b).

Figure 2.5

Advanced Manufacturing Technology Continuum

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Illustration removed for copyright restrictions

From Justification Techniques for Advanced Manufacturing Technologies, By J. Meredith and N. C. Suresh. International Journal of Production Research, Vol. 24, No. 5, 1986, pp. 1043-1057

Figure 2.6

Justification Approaches

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From Justification Techniques for Advanced Manufacturing Technologies, By J. Meredith and N. C. Suresh. International Journal of Production Research, Vol. 24, No. 5, 1986, pp. 1043-1057

In such cases the technology is often not justified and the company is deprived of an important asset. These benefits, in fact, may have shown up as further revenue even when they were not traced to the technology (Gerwin and Kolodny, 1992).

Porter, in his book "Competitive Advantage: Creating and Sustaining Superior Performance" (Porter, 1985) states that companies gain and sustain international competitive advantage through improvement, innovation, and upgrading. Sohal, Samson and Weill (1991), in their study of North America and Europe concluded that in creating excellence, manufacturing organizations need to consider investment as an critical part of their strategy. They have shown that the majority of methods used for evaluation in advanced manufacturing technology are improperly used. They propose that choice should be based on strategic and significant reasons and not only on traditional financial investment analysis. Another study by Sohal, Putterill and Maguire (1994) has found that the payback method was still the most frequently used technique among Australian manufacturers.

The traditional methods of economic justification, purely financial measures, have failed when trying to evaluate proposals for advanced manufacturing technologies. Considering only the effects of financial implications will not be the best way to evaluate the benefits an organization may receive as a result of adoption and implementation of new technology. While difficult to quantify, decreased time to market, improved quality, or reduction in design time, must be included in such assessments. Primrose and Leonard (1986) encouraged supplementing conventional cost measures with a quantification of the perceived invisible benefits. They have considered such factors as improvements in quality, reduction in rework, and shorter lead time producing a better response to customer requirements which may result in increased sales.

According to Kaplan (1984, 1985 and 1986) and Gold (1982) regardless of whether financial administrators accept a more multi-discipline part in analyzing financial data, it appears that strategies such as return-on-investment will need to be changed. They propose that financial departments review both the financial and non-financial principles of performance. This becomes even more important with implementation of advanced manufacturing technologies that would create an increased need to measure performance in non-financial ways, such as quality, inventory, productivity, and employees' commitment. In short, they say:

1. define existing situations and needs,
2. review objectives for the present & the future,
3. consider both direct and indirect savings, and
4. evaluate personnel selection and training programs.

Lack of effective implementation and justification can be summarized as insufficient, where often individuals in organizations simply did not understand their needs. An analysis that includes non-financial factors must be approached with caution to avoid some potential hazards that are caused by lack of communication and threatened personnel.

The need for, and importance of, budgeting and planning have been identified by a number of researchers (AECT, 1977 and 1989; Brong, 1972; Jamison & Klees, 1976; Hinz, Jones & Hinz, 1980, Merrill & Drob, 1977; MacKenzie, Eraut & Jones, 1970; Pennsylvania Learning Resources Association, 1970). Based on discussion in this section, perhaps the following approach would be appropriate where the need for technological change has been identified. First a system that identifies a percentage of total organizational budget to be allocated for technology adoption (AECT, 1989). The second model is based on a specific expenditure per product or product line (Allen & Allen, 1973; Pennsylvania Learning Resources Association, 1970). Within this model, either a fixed value or a percentage of expenditure is defined as the technology adoption budget, with no average or estimated ultimate value indicated by the experts in the field (Gillespie, 1983; Gillespie & Dicaro, 1981; the Pennsylvania Learning Resources Association, 1970 and 1981; Van Horn, 1980). The third model, according to AECT (1977), Brong (1977), and Merrill and Drob (1977), is where a center is provided with an amount of funding purely as a result of subjective value judgments. Totally unstructured, the funds are provided by the organization's central administration and can be supplemented at any time during a given period. In reality, the only determining factor in this model is the availability of funds within the organization (AECT, 1977 and 1989; Brong, 1972; and Severance, 1971). The fourth system is based on functions of a center within the organization (Brown, Norberg, and Srygley, 1972; Hinz, Jones, and Hinz, 1980; and Merrill and Drob, 1977) and is primarily concerned with the significance of benefits to be achieved. Annual allocations are based on priorities. Clearly this approach to budgeting emphasizes performance and therefore evaluates the outcomes for future planning (Merrill and Drob; Meisinger and Dubeck, 1984). The fifth system is used for planning and budgeting technology support in the organization. Within this model all activities related to technology are listed and a specific amount of money is allocated to each line item (AECT, 1977; and Brong, 1977). The sixth and the last is a method whereby planning is directly linked to the budgeting process and resource allocation (Meisinger and Dubeck, 1984). Because of the strong orientation to planning in this method, different alternatives are typically examined to determine ultimate solutions, past performance, and future needs. Therefore, value judgments are greatly reduced, if not totally eliminated (Brong, 1977; Jenkins, 1971; and Meisinger and Dubeck, 1984).

Although various models are explained here, identifying advantages and shortcomings of each may not always be used as an individual model by any organization. Variations of each model or combination of these can be used, depending on limitations and needs.

Although several costs; product cost, processing cost, inventory cost and others; are critical factors in making a profitable organization, one of the important areas within the implementation and justification processes is the cost analysis that is concerned not only with determining the control of cost but the benefits achieved from implementation.

2.6 Research Hypotheses

Hill (1994, p. 26) states that:

> "Companies require a strategy not based solely on marketing, manufacturing, nor other functions, but one that embraces the interface between markets and functions.... One illustration is the link between marketing and manufacturing."

For this strategy to be effective, proper data defining the organization's manufacturing skills needs to be available within a business, as well as the marketing information (Hill, 1994).

Within the area of management of technological change, engineering must be performed in context. What needs to be accomplished? How must engineers and other members of the organization react to new economic and societal contexts?

The use of technology in many cases establishes the realization of business activities, and technological change in turn creates a change in operations of the organization. Such use of technology then permits improvements in production and productivity, which subsequently may require reappropriation of resources and perhaps even the reevaluation of the productivity. Technology and the management today ultimately drive an organization's performance, and management of technology must be appropriately coupled with people and organization's management philosophy in providing effective solutions facing many industrial organizations today. In other words, technology and change have a direct effect on the working environment and the productivity output.

One of the most important tasks of management today is the ability to manage change and the subsequent effect in management and other functional areas of the organization. In today's environment, a new type of management is needed. As effective manager is one who is not only concern with financial performance of the organization, but also recognizes his/her ability to manage the causes of a firm's performance. This can simply be argued as the effective management of technological change. However, there are many factors causing adoption of new technology that are often difficult to determine. It is an accepted philosophy that the introduction of new technology is greatly inspired by potential profit which in turn affects the justification of resources needed and the way the new technology is implemented. Nonetheless, technology adoption, or technology change, is often justified on the basis of pure financial benefits, productivity growth, or simply cost savings. Yet justification on potential productivity increased is often an insufficient measure in the determination of true effects of technological change. This is because more efficient production methods and/or changes in organizational philosophy may affect this increased productivity.

There are mainly two reasons for technological change: first, within a business, which is the perception of an opportunity, and second in response to pressures from its market as a means of survival and/or prosperity. Stating it more fully; while many organizations consider technological change as a strategic issue, others simply consider it as the response to market and competition. Technological adoption, its justification and implementation are major components to the economic growth of the organization and should be important tasks of managers in decision making process. However, these tasks go beyond macro or micro economics of technology. More importantly, management of technology is a complex process, which is affected by both internal and external factors in which managers must develop a formal plan to evaluate and change processes. Mr. Smith, Chairman of General Motor Company, has emphasized that the "greatest need for a company today is the management of change and, in particular, technological change which requires effective technological planning and goal orientation" (Burns, 1984).

There are frequently major differences in the management of technological change. These may be due to the difference in management structure or other variables such as culture and social factors within the organization. On the other hand, there are other reasons for this lack of effectiveness, including perceived risk of change or the lack of adequate justification and evaluation. Executives at the top level of many industrial organizations must be aware of two problems: first, the management of technology and its adoption, and second, the management of change and people. Many of these executives in the U.S.A. know how to manage financial aspects of the organization, but they usually have less proficiency with the management of technology and people, which are at times left to lower level managers. A better approach, in justification and implementation, perhaps could be the creation of a team that is made from professional engineers or technologist where financial management responsibility is given to lower level managers. The strength of technological change rests on many details including the new technology, which should allow integration into current production systems while considering both external and internal factors.

In addition, other factors influential in the change process and variables in the management of change could include the choice of a particular technology, processes and timing of adoption, and the level of investment required for technological change. On the other hand, the implementation process could include alternative ways and the final method selected for implementation; sampling, testing and resources or operational planning; and most importantly development of a training and management program in support of this change.

The management of technological change is still undeveloped for many organizations. For example, Skinner (1978) investigated the reasons for failures in industrial plants in achieving organizational success and had identified the causes as a lack of integration and use of manufacturing policy. He has argued that for manufacturing to contribute to a firm's success, the key mission and objectives of manufacturing must be defined and that manufacturing personnel must be involved in the planning for technological change. Other researchers, Miller (1972) have developed models of manufacturing and its role in technological change.

The present study was designed to determine the consistency of the perceptions of technical and non-technical administrators in all food equipment and preparation industry in the United States of America towards the importance and commitment to technological change. Consistent and positive technical and non-technical administrators' perceptions of technological change could provide strong justification for increasing support for these changes. In particular, technical administrators, as primary users, are in an excellent position to evaluate the importance of various technologies. On the other hand, the non-technical administrators (financial or marketing administrators) are those who provide the resources for implementation. These administrators are responsible for prioritizing various services and making decisions about budget allocations. As a result, non-technical administrators' perceptions provide a basis for evaluating change and budget commitment to technological change.

Accordingly, three comparisons were made in the research. First, both technical and non-technical administrators' perceptions regarding the benefits of group technology were compared to determine their consistency. Second, technical administrators' perceptions regarding the benefits of group technology were compared among themselves to determine their consistency. Third, non-technical administrators' perceptions of the benefits of group technology were compared among themselves to determine their consistency.

The following hypotheses are investigated in this research:

1. There is no statistically significant difference between the technical and the non-technical administrators' perceptions of the benefits of group technology.
2. There is no statistically significant difference within the technical administrators' perceptions of the benefits of group technology.
3. There is no statistically significant difference within the non-technical administrators' perceptions of the benefits of group technology.

CHAPTER 3

MANUFACTURING SYSTEMS

3.1 Introduction

Manufacturing organizations are facing increased competition in terms of response time to customers (time to market), better quality products, available internal and/or external funding for research, day to day operations, and qualified and skilled personnel. These collectively could be defined as a systematic utilization of resources in a manufacturing environment. At the same time, available resources, especially human resources due to economic growth and market conditions (unemployment), are declining and as a result, it is critically important that advanced and different manufacturing systems be evaluated if further increases in resources are to be made and justified.

To ensure their continued existence, manufacturing organizations need to continually evaluate new technologies in order to remain competitive. Therefore, effective analysis and possible implementation of advanced manufacturing technologies have become ever important issues for many organizations. This research provides a review of the traditional as well as contemporary manufacturing systems.

For the purposes of this research, manufacturing and production management is defined as the organization, application, and effective utilization of human and non-human resources towards useful ends. As such, it should be clear that management efforts must be directed towards both technology and people, since both are required in today's manufacturing activities. Some common management theories have been identified as scientific management, where management problems can be solved by application of scientific methods that are used to look at "if ... then what" management issues. Since most management issues are a blend of different theories, not any one theory is emphasized in this research. Furthermore, production management includes such activities as planning, organizing, coordinating, and controlling, which ensures that the resources are used effectively and that the goals and objectives are achieved. Since the primary goal of manufacturing organizations, while providing necessary resources, is to deliver products of quality at the right time to their customers. It may be stated that perceptions of technical and non-technical administrators provide an important component in the evaluation of various manufacturing systems. Budget, personnel, and time commitment (resource allocation), toward adaption and implementation of new technology are also critical if manufacturing organizations are to be effective.

With this introduction, the remainder of this chapter is divided into five sections of: Manufacturing Development, Resource-Based Strategy within Manufacturing, Competitive Manufacturing (Production) Methods, Flexible Manufacturing, and Group Technology.

3.2 Manufacturing Development

The first industrial revolution started with the arrival of powered machine tools and the movement of people from farmlands to the factories. The second industrial revolution, the assembly line and mass production, began in the early 1900s. This new revolution had a tendency to be very large and costly in technique and systems. During the 1940s, this new system was fully developed and in most cases had large automatic material handling mechanisms from which the term "automation" developed. The aim was to amplify islands of automation, which today are referred to as fixed, in contrast to flexible automation that emphasizes programmable machines. The third industrial revolution, developed in more recent years, features computerized systems for control of both processes and entire manufacturing systems (Black, 1991).

As in the past, today the most significant factor in being a successful manufacturing company is the method by which the employees, materials, and wealth are organized and managed to provide effective coordination, responsibility and direction (Black, 1991).

Techniques of production management are applied in service operations such as maintenance and transportation, as well as in manufacturing activities. In an industrial or manufacturing organization, production management is defined as the planning and control of industrial production processes to ensure that they move smoothly at the required levels. Equally, Operations Management can be defined as the application of scientific methods to the management and administration of established commercial and industrial systems. As such, the Production and Operations Management function continues to play an important role in the strategy of all companies. Production and Operations Management provides directions and resources for the manner in which goods are made or services offered in the marketplace (Dilworth, 1986). Functions such as marketing and sales, finance and engineering are also important to the success of the business. However, production and operations management must consequently work with the activities of other parts of the enterprise to integrate the efforts of these functions. Furthermore, it accommodates various activities that occur within the production and operations function.

Management of production and operation, according to Dilworth (1986) consists of issues that are concerned with:

1. how managerial decisions are and should be made,
2. how to acquire and process data and information required to make decisions effectively,
3. how to monitor decisions once they are implemented, and
4. how to organize the decision-making and decision-implementation processes.

The use of more traditional disciplines such as mathematics and statistics, as well as recent scientific developments such as communications theory, decision theory, and organization theories, are more common in today's production and operations management activities. As such, the management function can be defined as having the necessary knowledge and skills to make effective use of people and machines to carry out the tasks of production.

In developing new products to replace old ones, technology and planning research, and the incorporation of research findings into profitable products are some of management's most difficult tasks. A number of mathematical techniques such as operations research, probability theory, queuing theory, simulation, transportation methods, assignment and simple methods, decision tree and Bayesian analysis, among others, are the most useful to today's managers (Moore, 1975) where each technique represents a path that leads to possible outcomes.

Internal conditions such as strengths and weaknesses, market understanding, existing products, personnel (skills and motivation), facilities, equipment, and capital are all diverse elements of the company's environment that must be evaluated for making vital decisions. However, the external factors such as economics, political, social and market conditions, customers, and technology are equally important and must be analyzed in setting the company's goals. Additionally, some of the trends such as current processes, procedures, and methods that exist in manufacturing will probably continue and will effect the overall efficiency and effectiveness of the organization (Dilworth, 1986). Other factors such as continuous improvements of quality and just-in-time production are global requirements for any successful manufacturing enterprise. Other trends such as flexible manufacturing, Computer Integrated Manufacturing (CIM), Computer Aided Design (CAD), Computer Aided Process Planning (CAPP), group technology, and cellular manufacturing are examples of the future trends in production and operation management which must be taken into account to ensure successful output.

There is a great deal that managers can do to help ensure success. These include:

1. involving potential users in the development process,
2. defining goals explicitly with a view to the decision they will assist,
3. expressing input/output in familiar formats,
4. defining roles clearly,
5. being opportunistic, and
6. recognizing that processes are individualistic and dependent on people.

Successful manufacturing organizations set clear goals in pursuit of their overall strategic objectives. This is winning manufacturing, a never-ending process based upon the long term commitment to a broad, common sense, structured process of continuous improvement. Just-In-Time (JIT), Total Quality Control (TQC), Statistical Process Control (SPC) have all been held up by management as tools for an ideal manufacturing environment. Successful firms must address these elements in today's global marketplace to obtain higher volume, and yet achieve and maintain manufacturing efficiency. They must also meet the high level of customization required by small production lot sizes. Manufacturing cost, marketing, product development, production and inventory control, quality, production lot size, and adaptability are all important manufacturing strategies. Yet another and perhaps more important factor, with an increasingly well educated work force, higher expectations and more mobility; is that managers ought to have even more interpersonal and organizational qualifications than technical expertise.

Managing a company in today's global environment is more demanding than before. Today, administrators of industrial establishments encounter a more challenging and involved role than any time in the past when associating the many unique and diverse corporate entities to the accomplishment of the business goals (Geralle and Stark, 1988).

Hill (1994) defines the function of manufacturing as taking inputs (materials, labor, ... and energy) and converting them into products. He continues to explain that:

> "Manufacturing is not an engineering or technology-related function.... Whereas products need to be made according to their technical specifications, they also have to be supplied in ways that win orders in the marketplace. This business dimension is the concern of manufacturing. When making decisions, therefore, on in which process to invest, companies need to satisfy both technical and business perspectives." (Hill, 1994, p. 93)

In recent years, an explosion of new technologies has brought new challenges and benefits to manufacturing organizations. To utilize these technologies, when changes are advancing so rapidly, and achieve effectiveness and efficiency, manufacturing organizations require a systematic method to plan, implement, and evaluate these technologies. However, before discussing the competitive manufacturing methods, it is appropriate to review and include the resource-based view of manufacturing in the next section.

3.3 Resource-Based Strategy Within Manufacturing

International competition drives the promotion of AMT and decisions made by personnel affect the implementation process (Gupta, Chen and Chung, 1995). It has been suggested that the implementation of AMT not only requires a capital investment, but also an organizational change that typically takes longer (Parsons, Linden, O'Connor and Nagao, 1991). It is also suggested that AMT implementation requires fulfilling technical, organizational and employee-related responsibilities (Blackler and Brown, 1985). Change management, within the manufacturing strategy, can be defined as two distinct yet dependent philosophies of competitive and resource-based strategies.

Skinner (1969) defined manufacturing's objectives as cost, quality, delivery and flexibility and indicated that there were tradeoffs between them. Hill (1989) and Platts and Gregory (1990) have suggested that these four basic objectives (cost, quality, delivery, and flexibility) can be tailored to the individual organizations where, for example, flexibility is a specific performance objective for a given company. These four objectives, when combined, become an overall strategy that allows for change when it is needed. Schonberger (1990, p.21) has stated "World class strategies require chucking the (tradeoff) notion. The right strategy has no optimum, only continual improvement in all things". Recently, others have argued the interaction between decision areas such as manufacturing processes and the impact of human resource policies on those policies.

Skinner and others, including Hill, Platts, and Gregory, felt that the resource-based strategy was the best way to implement change within the company. There are others that view implementation of change in a very different way. Most research during the 1970s concentrated on individual areas of content, while losing the holistic perspective Skinner had encouraged (Mills, Platts, and Gregory, 1995). This is not an entirely unrealistic approach. Others examined the economics of scale, and also took a view of factory organizations. Nonetheless, Neely and Wilson (1992) and Upton (1992) have reformulated these tradeoffs. Wheelwright (1981) has questioned the assumption by Skinner, noting that managers seek to improve quality while reducing cost simultaneously.

While Skinner and others formulated various related views on the implementation of change that led to an overall strategy, other, particularly during the 1970s, saw things in a more narrow sense. The only problem with this view of resource-based manufacturing is that there is no strategic component. Even though there is a place for this tactical or narrow view within the overall strategy, that strategy must not be overlooked.

The narrow view addresses a specific area of concern that may need change in order to improve efficiency. The strategic view should always have provisions built into it that allows for tactical changes. In other words, it is important to keep the overall strategy in mind while making tactical change.

Jacobson (1992) stated the idea of competence and capability, where the sources of a firm's competitive advantage was in unobservable factors (viewed from outside) rather than observable factors. Coupled with competence and capability is another unobservable factor, confidence. Being competent and capable is important in a competitive sense, but it is just as important to have confidence that what the organization is doing is the right move. In fact, Teece, Pisano, and Shuen (1991) described these factors as upstream, difficult to replicate resources, hard to change and it is such capabilities that provide superior product offering on which competition is based. At the same time, the concept of competence and confidence within the business strategy literature has regularly been described as the ability that sets a business apart from it's competitors and provide tangible benefits for the customer (Selznick, 1957; Peters, 1984; and Porter, 1979 and 1991).

More recently competence has been defined as the method of learning in the organization, how to coordinate various production skills, and integration of different technologies (Prahalad and Hamel, 1995). Many researchers have written about the notion of how competence is actually built over time and have stated that this is a developing area, which may provide for manufacturing strategies that are appropriate for firms pursuing a manufacturing-based competitive advantage.

When a manufacturing firm has confidence in both the strategy being employed and the product they are producing, then the firm has achieved a definite competitive advantage over their competitors. Combining competence and capability with that confidence enables a manufacturing organization to exceed it's expectations. This should be built-in as part of an organizations overall strategy.

The concept of strategy has been researched around a background established by Andrews (cited in Collis and Montgomery, 1995), who characterized strategy as the alliance between what a company can do and what it might do within industry. More recently, signs of new approaches to strategy were directed at addressing many violations on the provisions of strategic planning which were focused inwards. Other lessons from Peters and Waterman (cited in Collis & Montgomery, 1995) led the way, closely followed by TQM as strategy and re-engineering. Each made it's addition and yet, in turn, how many of them built on or contradicted to the previously accepted wisdom was unclear which resulted in compounded confusion about strategy. The resource-based strategy, a framework that has the possibility to cut through much of this confusion, is now rising from the strategy field. The approach is based on economics and demonstrates how a company's resources guides its performance. The resource-based view couples the internal and external analysis of the industry and the competitive environment. Therefore, the resource-based view builds on the two earlier approaches to strategy by bringing together internal and external perspectives and recognizes companies as different collections of physical and intangible assets such as human resources, skills and organizational structure (Collis and Montgomery, 1995).

The resource-based manufacturing strategy is one that asserts that a firm's inner processes constitute a collection of resources which can enrich the mechanism of developing and supporting a competitive edge. Concurrently, flexibility in manufacturing operations is accelerating and is perceived as a competitive value where, manufacturers develop a basis that will grant them the flexibility to efficiently strengthen their operations with the ever-changing objectives. One approach in achieving competitiveness, in addition to other systems, is through development and efficient use of the resource-based manufacturing where the organization's internal processes constitute a collection of resources and are used to enrich the mechanism of developing and supporting a competitive edge. The environment and the background of the resource-based strategy is one that is built, based on both manufacturing and business strategies, through systems such as cellular manufacturing, TQM, JIT, including aspects of people, skills and qualifications, capabilities, and culture. To the degree that the aspects of people, qualification, and their skill enhancement are concerned, they have been associated with operational performance improvements (Youndt, Snell, Dean, and Lepak, 1996).

In an era where product quality and mix, time to market, and customer satisfaction are becoming more important, and while technological changes are taking place faster than ever; they are all based on an organization's human and capital resources that contribute the means for further competitive advantage. For example, where cellular manufacturing or CAD/CAM are technological innovations, TQM and JIT are principally the managerial attitudes that apply to the way that management approaches manufacturing decision-making. Manufacturing adaptability can provide the organization with a sustainable competitive advantage, and the support for this view is found in the literature, case study and survey research (Hayes and Pisano, 1994; Upton, 1994; and DeMeyer, Nakane, Miller, and Ferdows, 1989).

While technology has received significant attention, and numerous firms have invested heavily in at least some level of technology, management still is challenged with survival in today's environment and how to sustain their competitive advantage. Some have conceivably put too much importance on technology performance and its integration without regard for employees training as a competitive advantage. Many organizations have had technical achievements with their technology implementation, but not many can say that their capital investments in manufacturing technology have been a business and financial success. A well thought out manufacturing strategy based on utilizing the best available technology, management techniques and systems can allow survival not only today, but also establishes the foundation for continued success. In other words, investment in technology as well as human resources are the variables that determine a business's potential competitive advantage in the marketplace. In the following sections, a brief summary of various manufacturing systems are provided with the application of each process.

Manufacturing adaptability can provide a firm with a sustainable competitive advantage and is viewed as a source of competitive advantage, consistent with a resource-based view of the firm (Hayes and Pisano, 1994; Upton, 1994 and DeMeyer, Nakane, Miller and Ferdows, 1989). The manufacturing firms hope to develop capabilities that will allow them the flexibility to realign their operations. One way to do so is through development and effective utilization of the workforce where literature review of the resource-based view of the firm builds upon the strategy content by noting that it is a firm's resources, which ultimately are the sources of its sustained competitive advantage. For example, two resource-based views (Ghemawat, 1986) have been developed:

1. An obtainable resource via market which are employed for competitive position, and
2. A resource-based view that emphasizes how generic factors are applied to specific activities to create temporary competitive advantage. These include human resource

practices, culture, team-based skills and hard to manage tasks (Schulze, 1992) but become valuable resources (Barney, 1986; Dierickx and Cool, 1989; and Robins, 1994) which satisfy Teece's (1987) requirements that competitive advantage is built on the interplay between core and complementary resources.

Manufacturing organizations are undergoing intense transformations today due to a dynamic global competition that is caused by globalization of companies, market fluctuation, economic growth, available workforce, and new technological developments (Katayama and Bennett, 1997). The logic connecting the human resources and firm performance is intuitively appealing and is supported by research from a number of theories including micro economics and human capital theories that suggest that people possess skills, knowledge and abilities that provide economic value. However, investment in training and education is only supported when they produce a future return such as increased productivity (Becker, 1976; Duncan and Hoffman, 1981; Barnes, 1984; Rumberger, 1987; and Tsang , 1987). From strategic management and organizational economics, the resources-based theory of competitive advantage focuses on the role internal resources like employees play in developing and maintaining capabilities (Barney, 1991; Wright and McMahan, 1992 and Wright, McMahan and McWilliams, 1994). In fact, numerous researchers have recently noted that people may be the ultimate source of sustained competitive advantage since other resources such as financial capital have been weakened by globalization changes (Reich, 1991). Furthermore, Pfeffer (1994) has made the case that organizations wishing to succeed must make appropriate human resource investment to acquire and/or build employees who possess the necessary skills to compete in the global marketplace.

3.4 Production Methods

3.4.1 Job Production System

In job production, products are completely manufactured by individuals or group of employees. Job production, a product-oriented infrastructure grouped with fixed position layout, is perhaps the most general and versatile type of established manufacturing systems. However, it is not generally practical, and does not make adequate use of capacity in most situations. The job system is considered to be a costly production system and is desirable for on-off order requirements of customers; for example, purpose-built tooling, or a printing business. In this system, use of resources is low due to duplication of facilities, where typically a variety of different products are completed in parallel, and skill specialization benefits are not realized. The job production system is the most general type of system that does not make use of the most basic resources. As a result, its' use is generally limited to specially built components made entirely to customer requirements such as ships, and buildings (Hill, 1994; and Bennett, 1986).

Although the review of literature indicates that this system is perhaps the most general and versatile type of manufacturing systems, it is not generally practical. Nonetheless, the application of this production system greatly depends on existing capabilities as well as the market demands. For example, as the production quantity increases, a job shop previously producing smaller quantities may now be able to produce the larger quantities in batches to increase its operational efficiency.

3.4.2 Batch Production System

The batch production is a system in which products are made in batches such that the repetitive costs are allocated between individual parts in the batch. In other words, the batch procedure divides the manufacturing task into a series of appropriate operations, which together will make the product involved. This, obviously, falls short of the adaptability of the job system, and because of difference in lot sizes in this type of production, unfinished parts will eventually end up waiting in queue at some point within the system (Hill, 1994; and Bennett, 1986).

The Institute of Industrial Engineers (1989, p. 17-3) in the United States has also defined batch manufacturing as "the production of parts in discrete runs, or batches". This system is a type of production used when the requirement for a commodity is small compared with the manufacturing capability and capacity. Products are manufactured intermittently in a quantity that meets a discrete demand until the next production run is initiated. In the interim between production runs, facilities may be used for other work in a comparable manner. The fundamental problem in this class of production (intermittent) is the optimum and economical lot sizes. Additionally, the order of production in which these economical lot sizes are run is difficult. Due to intermittent production and economical lot sizes, the batch quantities are frequently fixed in this type of production (Chase and Aquilano, 1992).

Batch production, perhaps the most common production system for many industries, has been identified as being more efficient when compared to the job shop. Nonetheless, there still remains the unfinished parts that will end up in queues due to different lot sizes and production runs. However, between the production runs, machines and equipment may and can be used for other work when the work is comparable, in order to maximize or increase the use of these machines. Just as with other production systems, market demand or customer needs will greatly affect the selection of a particular system.

3.4.3 Flow Production System

The flow or continuous production is one where the material is passed through successive stages and operations and refined into product(s). This process is based on high-volume nature and also requires that the material be moved easily from one part of the process to another that justifies the high investment costs involved (Hill, 1994). In this system, facilities are combined according to the successive operations by which products are made.

> "Flow systems are used for situations where production volumes are high, or continuous, and the rate of production matches that of demand. Processes are normally laid-out in operation sequence and work organization is generally task oriented, with people working in the system performing a confined task or restricted number of tasks on a repetitive cycle." (Bennett and Forrester, 1993, p. 302).

Various machines are grouped into a flow line and are frequently considered for the production of a specific product. As production skills are shifted to the machines, less direct manual labor is required. In this system, machinery and equipment are of particular importance. They are expensive to design and build and must operate for extended periods of time. It is only then that the cost of initial installment can be distributed over various units. It is for this reason that unnecessary changes in design must be deferred.

Few setups, low materials handling costs and low working capital are positive factors associated with flow production system. The undesirable factors of this system are mainly the worker recruitment problems, high absenteeism and inflexibility in both products and processes, and greater indirect labor requirements (Bennett 1986; Bennett & Forester, 1993). Although, the flow production has one of the highest production rates, Burbidge (1975) notes that machine loading should only incorporate operation times since component setting times are inconsistent (reduction in capacity).

In summary, the application of each system greatly depends on both existing capabilities and the customer needs. This is the relationship between the required volume, available equipment, and the market demands in terms of the quantity and time. For example, if a low volume part or product were to be made in a batch system, at another manufacturer with higher volumes, the efficiency of the operations would decrease significantly.

3.4.4 Job Shop Production System

The job shop in the United States, which is different from the Job Production System in the United Kingdom, is possibly the most general of production systems in which large varieties of components are produced with general function machines, according to the sales forecast for inventory.

Job production has ever-changing products, where planning and scheduling jobs demand considerable effort. All the components for a job must be scheduled to be completed at roughly the same time so that the product can be assembled. The most prominent benefit of this layout is in its capability to make a broad range of products, each necessitating its own operations. Products are dispatched through the particular departments such as lathes, drills, and others in a given order. Job shops also produce a wide variety of products that result in small lot size, often one of a kind. This system is frequently used for a particular order and products to satisfy finished goods' inventories. Employees have comparatively high skill levels to perform a variety of dissimilar tasks where general purpose machinery is required. Scheduling and managing operations in a job shop is a constantly changing task. Products often compete for use of the same resources. Job production delivers valuable insight into the complexities of scheduling and controlling operations. The manufacturing equipment can be designed for higher production rates. For example, automatic lathes, capable of retaining many cutting tools and spontaneously loading a new piece of stock, are used rather than an engine lathe. However, as the job production expands, long product throughput and large in-process inventories result.

In general, a comparison between the the job, batch, and flow systems can be summarized as (Bennett, 1986, p. 35):

The job system =	Product-oriented organization + Fixed position arrangement + low or unique demand
The batch system =	Process-oriented organization + arrangement by function + medium or intermittent demand
The flow system =	Tasks-oriented organization + operation sequence arrangement + high or continuous demand

A review of different manufacturing processes at a manufacturer of food equipment show clearly that in most companies an intermixed system exists. Two products at a food equipment manufacturer were examined and the conclusion was that a combination of several systems were used. These examples include the following products:

1. The slicer product: while the overall production is considered to be continuous, the many individual parts and sub-assemblies are made in a job and batch system. The slicer rods were purchased items that were sectioned, drilled, ground, and polished in a job system. This had been set up as a flexible system in which it had four machining centers using common tooling and automated milling machines and profiling. At any given time, parts could have been produced in one of the four machine centers. Upon completion of these operations, they were sent out, as batches, for plating and then returned for subsequent assembly work. Concurrently, the slicers' knives were produced in batches mainly due to volume and special heat treating that was performed at a different location within the plant. The slicer knives were processed in three turning stations, where they were simply turned as a continuous process at the first station. At the second station, they were processed as batches, while during this process, the system was a continuous system. The third station was very similar to the second station but performing other turning operations. These knives were then sent, as batches, to two grinding stations in which each constituted a continuous process of grinding. In addition, while the entire slicer assembly was considered to be a continuous flow production, the many models were treated in batches within this operation.

2. The meat grinder product: this commercial meat grinder consisted of a hopper, the mechanical drive system, an auger, and the cylinder head where the meat is forced through a plate and knife. The drive system

is made of gears, drive motor, and the transmission shaft and housing. The gears were cast in batches at the foundry, shipped to the plant where they were rough machined in a gear-cutting machine. They were then sent, as batches, for heat-treating and returned to the machining center for final finishing operations. Another manufacturer made the hoppers' sub and final assemblies in batches.

Hill (1994) claims that most businesses will select two or more processes as being appropriate for the products they manufacture, depending on factors such as volume requirements. The characteristics of the conventional production systems, as a summary, are presented in Table 3.1.

3.5 Flexible Manufacturing

A high degree of flexibility is required to:

1. resolve difficulties associated with multi-product and small lot sized production, and
2. remove uncertainty as to elements of production such as facilities, labor, and raw materials.

The manufacturing system that has such flexibility is called flexible manufacturing (Ham, Hitomi, and Yoshida, 1985). The concept of the flexible manufacturing system was first designed and introduced in the mid 1960s. It was known as "Molins system 24" and used for non-rotational parts (Williamson, 1967). A flexible manufacturing system is based on the idea of grouping equipment that can produce a diversity of related parts. As such, this is an extension of group technology concept that deals with small batch sizes or the changeover and set-up times. A flexible manufacturing system is a group of machines with programmable controllers connected by an automated material-

Table 3.1
Characteristics of the conventional production systems

	Characteristics \ system type	Job Production	Batch Production	Flow Production
Physical Facilities	Type of layout	Fixed position	By function	By operation
	Type of plant & equipment	Mainly general purpose	Mixture of general purpose & adapted	Mainly special purpose
Human Resources	Proportion of managers	Relatively few managers	Relatively more managers	Most managers
	Numbers of management levels	Few levels (i.e. shallow hierarchy)	Relatively more levels	Most level (i.e. deep hierarchy)
	Skills, numbers and type	Large number of 'direct' skilled operators	Moderate number & range of skills	Skills confined to 'indirect' functions, (setting, maintenance, etc.)
	Training requirements	Extensive training of most direct operators	Moderate training needs	Most training aimed at indirect workers
Material Control	Amount of product movement	Negligible movement of product	Extensive movement of part finished products	Minimum movement
	Queuing & work in progress	Dependent on resource availability & allocation	Long queues at facilities High work in progress	Limited queuing & lower WIPlevels
	Throughout time	Dependent on resource availability & allocation	Long throughput time compared with total operation time	Short throughput time
	Product range & quantities	high variety/low volume		Low variety/high volume
	Product cost	Low fixed/high variable costs		High fixed/low variable costs

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handling system. The system is consolidated through an intermediary computer so that it can produce a variety of parts that have comparable processing prerequisites. It can be put together with discrete amounts and combinations of machinery. Some of the advantages of flexible manufacturing systems include:

1. improved labor productivity,
2. reduced capital investment,
3. shorter response time,
4. reduced work-in-process time including cost, and
5. greater flexibility of the equipment, increased machine utilization.

However, like any manufacturing system, there are limitations to a flexible manufacturing system in which a large investment in the technology that is not preferred by management, but would rather make a succession of smaller investments over time. A study by Jaikumar (1986) compared the production of similar products in 95 companies in the United States and Japan. The results indicated that U.S. manufacturers are using the flexible manufacturing system very poorly.

> "The average number of parts made by an FMS in the United States was 10; in Japan the average was 93. ..... The U.S. companies used FMS the wrong way -- for high-volume production of a few parts rather than for high-variety production of many parts at low cost per unit. ..... Nor have U.S. installations exploited opportunities to introduce new products. ..... the United States is not using manufacturing technology effectively." (Jaikumar, 1986, pp. 60-70).

3.6 Development of Group Technology

Group technology was developed and applied extensively in the former U.S.S.R. as a result of a need to improve conditions of manufacturing in the small batch situation, due to lack of production aids (Gallagher, Grayson, and Phillips, 1971).

The first significant publication on group technology was in late 1950s when Mitrofanov published his book in the U.S.S.R. called "The Scientific Principles of Group Technology". This was the beginning of group technology progress. Mitrofanov was interested in improving the utilization of machine tools by decreasing the set-up time which was accomplished through classification of similar parts, which were then produced in the traditional methods. Concurrently, and some even earlier, the classification and coding systems were being developed and piloted in some European countries and in the United States. In contrast to Mitrofanov, these systems tried to eliminate or reduce duplication of parts at the design stage. Fully developed, these systems led to attempts to use them for grouping similar components together for manufacturing purposes.

There has been some misunderstanding over group technology or cellular manufacturing terminology. This had been induced by the different objectives from many participants and was thought to be the same as classification (Williamson, 1972).

Most of the early developments and applications of group technology were based on classification and coding, using information contained in drawings. According to Grayson (Gallagher, Grayson, and Phillips, 1971), in the early years, the major effort of group technology was on the progression of the setup of single machine tools to manufacture families of components. During the 1950s and

1960s, the numbers of factories employing this system grew from a few to hundreds in the former Soviet Union. However, the distribution of group technology and cellular manufacturing was not even over the industrial area. The application of group technology offered important factory improvements, a 20-30% productivity increase of a machinist, where in the case of line manufacturing, the labor productivity increased by more than 100%.

According to Hyer (1984, P.186) "Literature on the use of group technology among U.S. manufacturers has been limited. The first accounts of Group Technology (GT) use in the U.S. appeared in the early seventies and, in general, presented sketchy summaries of the application in one or at most a few firms." Generally, the commonality of the exposures of the organizations contained in these communications was quite restricted. In other words, the lack of detailed information on the firms and their use of GT has made it difficult to determine how and where GT could be used in U.S. manufacturing.

In a manufacturing organization, there is an apparent requirement to ensure that the flow, from raw material to finished goods, is accomplished as quickly as possible. For example, locating all lathes together in a functional layout will result in interruption and will slow down the flow rate.

Group technology practices were traditionally limited, however, and development and successful implementation of computer-integrated manufacturing through the application of part families have led to a revived interest in group technology. (Ham, Hitomi, and Yoshida, 1985).

Group technology is claimed to be a creative alternative to conventional batch manufacturing. It attempts to solve small batch production by capitalizing on the similarities of components and assemblies. In addition, group technology frequently refers to the arrangement of technology and work force into work units (cells) with the aim of manufacturing related parts that are similar in their processing requirements (Dawson, 1991). An application of group technology, cellular manufacturing, is where a firm's manufacturing system (in whole or partially) has been converted to cells. A manufacturing cell is an array of dissimilar machines and processes, located in close proximity, and devoted to the manufacture of a family of parts. The cell system is a system of production that differs from, but complements, flow line production and traditional job and batch production. It is also based on a simple idea in the field of group technology.

Pullen (1977, p.451) defines a cell as follows:

> "A cell is a part of a larger manufacturing shop and is responsible for undertaking a sequence of functionally dissimilar operations on its component batches. For a cell to remain an economically and socially viable manufacturing unit over a useful time span its facilities must be closely grouped, it must have flexibility in its mix of capacity, be large enough for the cell to continue functioning with a single absentee and be small enough for detailed control to be practical by an individual."

3.6.1 Application & Extent of Utilization

There is no doubt that group technology and cellular manufacturing represent major technological innovations to many organizations. Most manufacturing systems today are hybrid systems: they are neither job, flow, nor cells, but rather an alliance of interrelated subsystems. Cellular systems are mostly associated with low to mid-volume parts fabrication, and can achieve the efficiency of assembly line operations (Wemmerlov and Hyer 1987). Group technology is an approach to organizing manufacturing activities that can be applied in many industries. The perception, however, is simply to recognize and group similar parts and processes to take advantage of the similarities during all stages of design and manufacture (Gallagher and Knight, 1986).

The use of group technology in a manufacturing organization requires two basic steps. The first step is the determination of component families or groups. The design of parts is reviewed to organize families of components that have corresponding features. The second step is to map out the plant's equipment into cells, each having the equipment used to process a family of components. There have been many applications of group technology in many areas of operations from design and planning to the organization of manufacturing activities (Gallagher and Knight, 1986).

Along with design and manufacturing, other areas of business operations could also benefit from group technology. For example, when applied to purchasing, it will help to reduce the proliferation of purchases of dissimilar parts. However, manufacturing remains the one area where group technology is largely employed. Within the manufacturing organization, production planning and control, process planning, parts design, and manufacturing are the important tasks that can be improved through group technology (Hyer and Wemmerlov, 1984).

Group technology, although used in many operations, as illustrated in Table 3.2, has been predominantly applied in the engineering and electronic industries. It has been used in factories making a wide variety of different products. It has also been successfully used in the mechanical engineering processes. Within mechanical engineering, group technology has been used with metal cutting, sheet metal

Table 3.2
Industries Identified as Group Technology Users

Aerospace
Agricultural Machinery
Automotive
Business Machines
Cargo Airplanes
Control Devices
Diesel Engine Assemblies
Envelope Machinery and Accessories
Heavy Duty Trucks
Hydraulic Pumps and Valves
Industrial Lift trucks
Lamp Making Machinery
Machine Tools
Machine Parts
Manual and Hydraulic Service Tools and Equipments
Mechanical Seals, Hydraulic Check Valves
Nuclear Weapons
Oil Wells

From The Potential of Group Technology for U.S. Manufacturing by N. L. Hyer. Journal of Operations Management, 4 (3), p. 183, May 1994 forming, and casting, while within the electronic industry it has been used in circuit card assemblies (Burbidge, 1975; and Wemmerlov and Hyer, 1989).

Group technology production methods are closely associated with design variety reduction and standardization, particularly as these procedures require the classification of components. This basic approach can facilitate the development of more rationalized and automated procedures for design (Gallagher and Knight, 1986). Within design, group technology may have three purposes. First, application corresponds to the creation of a classification and coding system so that drawings may be retrieved and amended rather than creating new ones. Second, matrices can be established for part families to distinguish the many design varieties which may be used for generating design standards for the family of parts. In the third and final process, group technology is used to focus on the organization's value and human engineering efforts.

According to Gunn (1982) research has shown that in many companies only 20 percent of parts thought to require new designs truly need them. Of the remaining new parts, 40 percent could be created from an existing design and the other 40 percent could be made by modifying an existing design. As such, according to Massey and Fletcher (1987) design and manufacture of parts is the idea of group technology. Some of the results obtained include:

1. reduction in part numbers,
2. simplified production planning,
3. improved introduction of changes to data, such as, change in a particular manufacturing process that can be applied to the entire group rather than individual parts,
4. simplified part identification through classification and coding, and
5. improved cost estimate analysis.

An increase in machine capacity, reductions in tooling investment, and operating costs are other significant benefits obtained through reduction of the setup time with group technology. Additionally, supervisors of the cell will be able to optimize schedules and better control the output rate (Burbidge, 1975). According to Perrins, Hawkins and Craven (cited in Gallagher and Knight, 1986), Alfred Herbert was a general engineering company which manufactured machine tools and developed an extensive cellular layout using a formal classification system for the components produced. This medium-to-heavy engineering company produced machine tools, incorporating a wide variety of parts. A functional layout incorporating over 1050 machines in two factories was used. The main problems arising from the existing methods were long manufacturing lead time and excessive stock of finished parts and work in progress.

The primary aim behind the development of the cellular system was to reduce lead time and work in process. Through application of parts families and cellular layout, lead time was reduced to 3 weeks from 36 weeks in one cell and from 18 weeks to 3 weeks in another. Work-in-process was also reduced by 92% and 72% respectively in the same departments.

Ferranti is a high technology company that produces avionics equipment for government use. Some 5000 people were employed, of which 350 were in the machine shop. The company, according to Durie, Allen and Burbidge (Gallagher and Knight, 1986), is an example in which it developed an extensive cellular layout, after initial success with cells for readily identifiable families of parts. The initial families were selected with little reliance on formal classification. The cellular manufacturing layout evolved over a number of years and later encompassed the whole machine shop with shorter lead time.

A detailed review of various classification and coding systems, and Production Flow Analysis is provided in Appendix B. However, because of the importance of the benefits and limitations of group technology, the next section provides a summary of these benefits and limitations that are well documented.

3.6.2 Benefits and Limitations of Group Technology

To evaluate any type of profitable investment, the anticipated advantages must exceed the expected expenses.

> "In a 20 - company survey, GT was given credit for reduced tooling and fixture expenses, reduced material handling cost, reduced need for floor space, reduced lead time, reduced work-in-process inventories, improved quality, increased worker satisfaction, reduced design efforts, easier design retrieval, and easier and more accurate cost estimates." (Hyer and Wemmerlov, 1984, p. 148)

By grouping the essential machines to make a family of parts, this type of production has generated savings in time and resources. It also provides an opportunity for the employees to set up their work within each cell. According to Fazakerley (1974 and 1976), group technology has been working in different industries. The uses of group technology have brought increased control throughout manufacturing and design processes. It has also improved management information and enhanced production quality. In general it has brought considerable cost savings. Table 3.3 offers a summary of some of the important benefits that are achieved by group technology. The predominant ratio of the time savings results from reduced time among transportation, set-up and throughput time, less work in progress and queuing that are inherent in functional layouts Table 3.4. These and other advantages of group formation result in manufacturing cost savings. The range of these savings depends on the individual manufacturing condition and product line (Gallagher and Knight, 1986).

The principal characteristics of group technology are group layout, short cycle flow, and a planned order of loading. Individually used, they will not produce savings. However, used together, it is claimed, they generate significant savings, and also create an environment in which even more savings can be obtained. A number of the benefits attainable with group technology are derived from the use of group layout. Major benefits include (Burbidge, 1975):

1. Reduced Throughput Time: the functional layout is associated with long throughput times. A batch of parts or components will be completed in each section before it is sent on to the next. It must wait in the queue, at the next section, for its turn to be processed. With group layout, component throughput times are reduced due to reduced queuing or travel time. This is because machines in a group are close together so that continual throughput is practical. The reduction in throughput time has some immediate and direct advantages; namely shorter deliveries.

Table 3.3
Reported Benefits Associated with group Technology

52% reduction in new parts designed
10% reduction in number of drawings through standardization
60% reduction in industrial engineering time
20% reduction in production floor space required
45% reduction in scrape
80% reduction in production and quality control cost
69% reduction in setup time
70% reduction in throughput time
82% reduction in overdue orders
42% reduction in new material inventory
62% reduction in work in process inventory
60% reduction in finished good inventory
44% reduction in stocks
48% reduction in stock/sales ratio
33% increase in employee output per unit time
32% increased in sales

From The Introduction of Group Technology (p. 52) by Burbidge, J. L., 1975, A Halsted Press Book; and The need to Predict the Potential for Group Technology in Manufacture (pp. 9-15) by Dale, B. and Willey, P., Machinery and Production Engineering, January 1977

Table 3.4
Contribution to Manufacturing Costs

MANUFACTURING COSTS

(1) Capital Cost

(2) Pre-production Costs
- Planning
- Data Preparation
- Jig & Tool Design
- Jig & Toll Production

(3) Annual Running Costs
- (i) Direct Labor
- (ii) Indirect Labor
- (iii) Maintenance
- (iv) Consumable
- (v) Tool & Fixture Maintenance, Storage & Interest
- (vi) Fixture & Material Preparation
- (vii) Tool Setting & Grinding
- (viii) Space Occupied
- (ix) Power & Heating
- (x) Inspection
- (xi) Insurance
- (xii) Transportation Between Operations
- (xiii) Scrap & Reworking
- (xiv) Work in Progress
- (xv) Material

From Group Technology Production Methods in Manufacture (p. 75) by Gallagher, C. C. and Knight, W. A., 1986, Ellis Horwood Ltd.
Copyright by Ellis Horwood, 1986

2. Increased Ability to Keep Up with Market Changes: one major benefit of the reduction in throughput time is that it allows a reduction in order cycle that increases capabilities of production to follow changes in the marketplace more quickly. Any decrease in cycle time reduces all time ahead for which a business forecast of future sales must be made.

3. Reduced Stocks: a reduction in throughput times will immediately reduce both work-in-progress and finished product stock.

4. Devolution of Responsibility: an important advantage of group layout is that the responsibility for producing each component in one group is centered on the cell. The foreman of such a group, typically, is responsible for quality and completion of work by the scheduled date.

5. Reduced Handling and Setting Costs: with group technology and cellular setup, all machines used to make each part are together. This reduces the handling and setup cost.

6. Reduction in Paper Work: another advantage is the reduction in necessary paper work. Since the operations for each part are completed in one group, necessary documents such as requisitions, move tickets, and progress documents are greatly reduced. The reduction in paper work also leads to a reduction in clerical costs.

7. Improved Human Relations: one of the major effects of group layout is an improvement in human relations. Two potential interpretations can be given:

A. group layout provides separate groups of people, working together, with an important and easily recognized task completion stage, and

B. group layout reduces the coordination needed in production that takes place inside the groups.

8. Reduced Investment per Unit: The savings in space with group layout are partly due to the reduction in work-in-progress and partly because fewer machines require direct access. Since the reduction in setting time increases capacity, the investment in machine tools per unit of output is also reduced by group layout.

Besides its significant economic benefits, group technology is also a desirable change from the human point of view (Burbidge, 1975). Implementation of groups of people working towards common goals in a group technology and cellular manufacturing system will result in delegation of more decision making at lower levels. This will provide for more individual participation. This, and simplifying the material flow, will reduce centralized bureaucratic control and thus, could provide for a closer coordination between particular departments and will greatly reduce conflict.

Individual employees differ in their needs, ambitions and levels of satisfaction. There is some indication that the working conditions with group technology are more desirable to humans than those by the alternative systems of production. Group technology, as a concept, is capable of being applied in different situations (Astrop, 1975), some of which may be seen as a potential for social change. A common desire to increase motivation, job satisfaction, and working conditions is achieved through group technology. Burbidge (1975, p. 260) asserts that:

> "The economic effects of group technology are of major significance, but it is possible that in the long run its sociological effects will be of even greater importance."

Cellular manufacturing, an application of group technology, portrays sociological units conducive to team work (Fazakerley 1976, Huber & Hyer 1985). A cell differs from the functional layout in that employees may be cross-functionally trained in all the areas within the cell, allowing adoption to the processing requisites of several products within a family. Considering that each cell makes products that have similar characteristics, product changeovers are simple to achieve, and small lot sizes may be justified economically (Brown, 1991). Restoring a traditional job shop with cellular operations changes the physical work environment.

There is some evidence from sociological research, and from practice, that the following factors contribute to the results (Burbidge, 1975):

1. Task Complexity and Cycle: there is indication that individuals do not like repeating very simple tasks of a very short cycle, and that this type of division of labor does not deliver the most economical production. An increase in motivation and production rate has contributed to task complexity according to E. Heckshaw (Burbidge, 1975).
2. Diversity of Work: another component that may affect job satisfaction is the variety of tasks that is possible. An employee in a polishing section may move from one polishing machine to

another during his work, but all the tasks he does will be similar. In group technology, on the other hand, an employee will have the chance to learn to operate various types of machines.

3. Group Satisfaction: there is evidence that humans have a strong need to belong to a group, and to cooperate in the achievement of common goals. Evidence of the sensibilities of workers toward mass production and assembly line work can be found in high rates of turnover and absenteeism. In the past, Chrysler Corporation, in the U.S.A., was reported to have a labor turnover of 45% annually and Volvo in Sweden employed an excess labor force of 14% as a buffer against absenteeism.
4. Product Satisfaction: a major factor in job satisfaction is the desire to finish products to a significant and easily recognized stage of completion. People who work in groups tend to get greater satisfaction.
5. Participation: finally, a principal desire for job satisfaction is employee participation in decision making. Most of the effort in this area, in the past, has involved such issues as employees' committees and directors. What most workers want is a more important role in the day-to-day handling of their own jobs. There are group technology applications where people in the groups decide who will do which

jobs, who can take a day off, and how shifts should be organized.

In specific, Burbidge identifies certain advantages with work groups for assembly:

> "Perhaps the most surprising development in group technology is that recently, companies as internationally famous as Phillips, Volvo and Saab have actually preferred group production - in cases where line production could have been used - for personnel relations and quality control reasons." (Burbidge, 1975, p. 147)

It is not implied that these are the only factors affected in group technology, and that these will deliver spontaneous improvements. In fact, Rathmill and Leonard (1977), have argued factors that, when compared with efficient functional layouts, are considered as principal limitations of group technology and cellular manufacturing. These include the cost of work-in-progress and machine idle time. Other factors, from a human relationship point of view, include job satisfaction, workers' mobility, and management of cells. Regardless of the savings that cellular manufacturing can achieve, it can not be implemented in all types of productions or organizations. We, as human beings, usually dislike change even when change is for the better. This system of production not only changes the relationships, it changes the work itself (Fazakerley, 1974 and 1976).

The major disadvantages of cellular manufacturing include unbalanced distribution of the workload within cells and the disruption impacts of machine breakdown (Askin & Subramanian, 1987). As with any technology or process, there are limitations to group technology. The drawbacks or limitations are those inherent in any new management process. Each company will run into its own set of puzzling blocks and resistance. However, certain issues surface in every application. The major personnel limitations that arise when group technology is introduced can be divided into five categories (Fazakerley, 1974 and 1976):

1. The uncertainty and insecurity that is felt by the employees affected. One of the primary factors usually neglected in industrial organizations is that employees at all levels tend to feel incomplete in the face of change. Many people who view group technology in the company's interest resist it from a personal viewpoint. Whether one is purposefully occupied or not, tends to be less significant than the idea of doing what is needed. The occurrence of this fact is often associated with the position of those accountable for implementation of group technology. However, when adequate training has been provided for these individuals about the change, they have become more dynamic and responsive.
2. Upper management must understand the underlying principles of innovation. Neglecting this, the business can neither plan group technology nor implement and control it. Many companies fail in the application of innovations because they assume that if they can announce that a new plan is rational it will be accepted. This is seldom the case.
3. It is presumed that grouping of machines into cells will bring closely harmonized groups. However, in many cases there is little, if any, integration. Major reasons for this may be:

A. Physical Placement of Machines: few organizations locate their machines with any regards of how best to develop social integration. Available space, the existence of equipment, outlets and other factors will affect the placing of machines; but in most cases a more detailed investigation could indicate alternatives that would be equally viable.

B. Low Degree of Commitment to Work as an Activity: the most general approach to work is that it is a paid activity demanding effort. Individual work obligation is a balance between the need to gain a satisfactory income level and the desire to express one's individuality in non-work activities.

4. The breakdown of tolerance that accompanies numerous changes. Conveying any change of significance is a trend for a company to become less tolerant. While this may provide for better efficiency, typically there will be an atmosphere of distrust from the shop floor. This requires a better managerial awareness.
5. Lastly, the question about encompassing the development of an adequate wage system is considered. Acceptance of change is obstructed whenever individuals feel they may experience financial loss as a result of their increased flexibility. Offering cellular manufacturing and group technology into an incentive payment system may mean there is a disincentive to change.

3.7 Conclusion

Manufacturing, in general, can be defined as the effective application of management of materials, people, and equipment to produce products. While this chapter has been a review of the different manufacturing systems, it is important to realize the relationships, and different aspects of the management of manufacturing to design, planning, and production.

Just as manufacturing management today is different from how it was in the past, tomorrow it may be different from today. More diverse and complex systems will be developed which will bring new changes and challenges to managers who may have to work within the infrastructure of more restricting constraints. Even though the current manufacturing environment is not new, more work will have to be done in the future with respect to better educated (job specific) and successful employees, innovative manufacturing techniques, and perhaps even increased social responsibilities. This means that management will have to make difficult decisions on whether the current production systems are good or bad, and the need for change.

Perhaps one of the more important relationships in manufacturing is that between design and production, where small changes in design could have tremendous effects on the production floor. For example, the establishment of classification and coding facilitates the development of more rationalized and automated procedures for design (Gallagher and Knight, 1986). These can then be used for part families and production methods.

Whether job, batch, flow, or other production systems, management's full understanding of the concept of need for change, processes, implications, required resources (financially and otherwise), and proper training of all personnel, including line and senior managers, is necessary if the implementation of new system(s) or process(es) is to be successful and the potential benefits achieved.

While this chapter has introduced the many types of manufacturing systems, both in the United States and the United Kingdom, the discussions have pointed out the applications, advantages, and limitations of each production system. Use of one or a combination of these systems relies on many internal and external factors associated with the organizations' activities. Hill (1996), notes that:

> "The management of the operations function comprises two principal roles - different in orientation but part of the same whole. Managing the broad set of tasks and responsibilities typically comprising the function continues the operational dimensions of the job. And, bound up with these is the need to undertake them efficiently. The other principal task is to develop a functional strategy which concerns prioritising the investments and envelopment within operations in line with the needs of agreed markets ...the failure of companies to understand their market and manufacturing's continued, reactive response in the corporate strategy; debate has led to a number of inappropriate responses within the operations function."

Management of manufacturing operations is a complex set of tasks that are affected by many factors including (Katayama and Bennett, 1996 and 1997):

1. Governmental regulations: where they apply to such areas as the environment, safety and product liability which all affect the way operations are run;
2. Economy: these conditions influence the demand for products, availability of raw materiels, and fluctuations in workforce that influence the decisions management make;

3. Competition: while in today's environment many manufacturers trade within and outside their political/geographical boundaries, factors such as transportation and communication systems have become important elements of daily operations;
4. Customer expectations: this refers to both consumers and industrial customers that are much more demanding in term of pricing, quality, delivery and flexibility; and
5. Quality: meeting quality expectations is not sufficient anymore, and any more manufacturers need to exceed these expectations.

In other words, manufacturing organizations not only design efficient and effective systems but must also manage these systems to make the best use of workforce, capital and materials. In conclusion, while some technologies such as GT or FMS are means of increasing the resource efficiency, it can be said that there are a number of external and internal factors that affects the need for change, justification and implementation of any new technology (Katayama and Bennett, 1996). These external elements among others include, and especially for those international organizations, such areas as:

1. Exchange and interest rates,
2. Supplier and customer relationships,
3. Consumer and market demands,
4. Distribution systems and available workforce.

Equally important are those internal factors that affect the daily operation and effectiveness of an organization. These include such areas as:

1. Organizational culture and structure,

2. Available internal workforce and the organization's ability to train its employees, and
3. Internal distribution system.

In short, these external and internal elements must be evaluated in details both through the justification and implementation processes. It is also equally important through these processes to include all resources, or lack of, with the competitive advantages that are obtained from particular manufacturing or production systems.

With a better understanding of these various systems, and especially the utilization, benefits, and limitations of group technology, the next chapter (Chapter 4) will outline the methodology, research methods, research design, and selection of the population. Chapter 5, will then present the empirical research including questionnaire, data collection, procedures for data analysis and results.

A series of case studies, including organizations outside the targeted industry, will then be presented in Chapter 6 in order to broaden the scope of the research. And finally, Chapter 7 will present research findings, discussion and a few recommendations.

Chapter 4

Methodology

4.1 Introduction

In Chapter One (Figure 1.2) a brief description of this research's methodology was given. This chapter describes the research methodology. It also explains the research methods, and finally establishes the research design, selection of the population and sample, and the procedures used to develop the research instrument. Before attending to these areas, a detailed review of various methodologies is provided.

4.2 Research Methodology

A primary goal of research design is to develop methodology which can answer a research question or test a research hypothesis with a high degree of confidence; i.e. to find strong evidence to support or refute a given claim (Borg and Gall, 1983). Research procedures should provide control over the condition(s) under investigation. As a result, the type of design will increase the level of confidence in the results (Bieger and Gerlach, 1996). There are two overall methods of conducting research: quantitative and qualitative. Quantitative design includes the measuring of variables such as traits, characteristics or other attributes; whereas qualitative research involves the investigation of meanings, concepts, symbols or descriptions (Berg, 1989). A primary goal of either method is to add to the body of knowledge by providing empirical answers to various questions presented (Fubara and Mguni, 1995). Furthermore, some questions are best answered by a combination of both quantitative and qualitative studies.

At this point it is beneficial to provide simple definitions for both 'method' and 'methodology'. Leedy

(1993) defines these as:

> Method: a simple way of accomplishing an end result. It is how one operates, a way to get the job done.
>
> Methodology: the study of a particular method or methods for reaching a desired end. The methodology, therefore, is an operational framework, a continuing, ever-changing and developing process.

Leedy continues to explain that it is important to recognize the fact that data and methodology are inextricably interdependent. He has identified four types of research approaches or methodologies:

A. Qualitative methods:

1. The descriptive survey (qualitative) method that is appropriate for data derived from simple observational situations. This includes both physical observations and questionnaires. This is also referred to as normative survey method that is employed to process the data that come to the researcher through observation. This is direct data, as distinct from historical data, which come to the researcher through written records.
2. The historical (qualitative) method that is appropriate for data that are primarily documentary in nature or literary in form. As with other types of research, it deals with the meaning of events.
3. The analytical method (quantitative) that is appropriate for data that are

quantitative in nature and require statistical assistance to extract their meaning. These procedures include such statistical analysis as central tendencies, means, and correlations.

4. The experimental method (quantitative), appropriate for data, is derived from an experimental control situation. This method mainly deals with the phenomenon of cause and effect.

According to Yin (1994), the case study method is yet another one of the many ways to conduct research. Other ways include such methods as experiments and surveys that were described in the previous section.

However, case studies are the favored strategy when "how" or "why" questions are being posed, and the researcher has little control over events. According to Hamel (1992) and Perry and Kramer (1986), case studies are increasingly used as a research tool. The case study promotes solely the understanding of the individual, organizational, and social phenomena. The case study has been a prevalent research tactic in psychology and political science as well as business and planning (Yin, 1993). In brief, the case study permits a researcher to maintain the meaningful characteristics of real-life events, such as organizational and managerial processes. A case study is an investigation that explores a contemporary phenomenon within its real-life context when the borders between phenomenon and context are not clearly apparent. Furthermore, a researcher would use the case study method because he/she purposely wants to cover contextual conditions that are appropriate to the study. Even though surveys can try to deal with phenomenon and context, their adequacy to investigate the context is limited. The researcher, in a survey for example, continually strives to limit the number of variables to be analyzed, or the number of questions asked. The case study as a research strategy incorporates a comprehensive descriptive method in order to include specific approaches to data collection and analysis. In this sense, the case study is neither a data collection tactic nor a feature alone (Stoecker, 1991).

Case studies can include, and even be limited to, quantitative evidence. According to Cronbach et al. (1980), Guba and Lincoln (1981), Patton (1980 and 1987), U.S. General Accounting Office (1990), Yin (1993), Smith (1990), and Stake (1986), case studies have a unique place in assessment research. There are five different applications:

1. To explain the causal links in real-life interventions that are too complicated for the survey or experimental strategies.
2. To delineate an intervention and the real-life context in which it occurred.
3. To explain by example certain topics within an examination.
4. To investigate those situations in which the intervention being evaluated has no clear or single set of outcomes.
5. The case study may be a 'meta-valuation' - a study of an evaluation study.

As with any research, but especially for case studies, five components of a research design are important (Yin, 1994):

1. Study questions: The first component forms the question in terms of "who", "what", "where", "how", and "why", providing substantial evidence concerning the most pertinent research strategy to be used.

2. Study proposition: Each proposition guides attention to something that should be examined within the scope of the study.

3. Unit of analysis: This third component is related to the central problem of defining what the 'case' is.

4 and 5. Linking data to proposition and criteria for interpreting the findings: These components have been the least developed in case studies. They symbolize the data analysis steps in case study research, and a research design should lay the foundations for this analysis.

A case study protocol is more than an instrument. The protocol consists of the mechanism, but also contains the process and general rules that should be followed in using the mechanism. Having a case study protocol is advantageous under all environments, but it is the key if the researcher is using a multiple-case design.

One of the most meaningful sources of case study data is the interview. Such a presumption may be surprising, because of the actual alliance between interviews and the survey method. However, interviews are also necessary sources of case study information. The interview may take several forms. Most commonly, case study interviews are of an open-ended nature, in which the researcher asks key respondents for the facts on a matter as well as for the respondent's opinion about events. In some situations, the researcher even asks the respondent to suggest her/his own insight into certain developments. Another form of interview can be one that is focused. In this case, the interview still remains open-ended and assumes a traditional manner but the researcher is likely to be following a set of questions derived from the case study protocol. Yet another type of interview necessitates more structured questions, similar to the line of a formal survey. Such a survey could be designed as part of a case study.

In research, questions can be posed to two groups: a smaller group that is the subject of a case study and a larger group that is the subject of a survey. The answers are equated for cohesion, where the case study can allow insight into the unique processes, and the survey can provide some indication of the prevalence of the phenomenon (Yin, 1994).

4.3 Research Methods

According to Schultz (1978), and Borg and Gall (1983), there are several commonly used procedures in conducting research. The purpose of the research, or the research questions to be answered, frequently determines the most effective method to be used. These can generally be divided into:

1. The experimental method: the essence of the experimental method is to investigate one influencing variable at a time while holding the other variables constant. The experimental method is used to establish causal relationships when proper controls are used. The variable being investigated is called the independent variable and the resulting behavior is called the dependent variable. To properly conduct an experiment, the subjects must be divided into two groups and must be as similar as possible:
   (A) the experimental group: An experimental group is one in which subjects are randomly assigned to groups that

experience controlled interventions manipulated by the experimenter according to a logic allowing causal inference about the effects of the interventions under investigation; and

(B) the control group: where subjects used for comparison are not given a treatment under study or do not have a given condition, background that is the object of study. Control conditions may be concurrent or historical.

2. The naturalistic observation method: one weakness of the experimental method is the artificiality it might introduce into the study. To avoid such factors, it is sometimes preferable to conduct a naturalistic observation; an observation without introducing any manipulation of the independent variables. However, the difficulty with this method is to reach a conclusion with little assurance. Another limitation is that the observation cannot be repeated or duplicated under the same exact conditions.
3. The causal-comparative method: this method is aimed at the discovery of possible causes for the phenomenon being studied by comparing subjects in whom a characteristic is present with similar subjects in whom it is absent, or present to a lesser degree. This research method, however, is only used to explore unique relationships, not confirm them.
4. The correlational method: this method attempts to discover and clarify relationships through

the use of correlation coefficients. The magnitude of the relationship between two variables is determined. However, it cannot establish whether one variable causes another or whether a third variable may have caused both initial variables.

5. The survey method: this method of research focuses on attitude and opinion rather than subjects as in the experimental or naturalistic methods. Regardless of the survey method, two issues must be resolved: (1) the format of the questions to be asked, and (2) the people to be questioned. In determining the questions to be asked, there are generally either open-ended questions or fixed questions. Although the open-ended questions allow the respondents to freely present their answers, its usefulness is dependent on how well the respondents are able to verbalize or articulate their thoughts. The open-ended question method can also be very time consuming if there are many questions. The same questions can be asked in a fixed question method, where the respondents have a fixed number of answers. The second issue in the survey method is the selection of the people who will be questioned. It is usually difficult to investigate the entire population. Therefore, the selection of a sample that is representative of the population research study is a critical decision that challenges researchers.

The survey method of research is typically divided into three categories of (1) telephone survey, (2) mail survey, and (3) personal interview. Telephone surveys costs less than personal interviews and could reach every person in the sample provided everyone could be contacted by telephone. The mail survey is more convenient and can reach a large number of people over a wide geographical area. Those in the sample can remain anonymous if necessary. However, the difficulty of obtaining a sufficient number of replies is the major limitation of this method. Lastly, the personal interview is usually the most time consuming, but can be used for all purposes of survey research. This method yields a greater level of accuracy and allows the researcher to elicit comments which are difficult to obtain in either the telephone or the mail survey. In addition, with rapid advances in computers and electronic mail technology, e-mail surveys may become a viable method in research.

4.4 Research Design

This study employed two primary methods of analysis: a survey questionnaire and case studies. The use of a survey questionnaire was necessary because:

1. the size of population in the study was fairly large and thus a mail survey was the only practical method to gather the necessary data;
2. survey respondents were dispersed across a large geographical area (the entire United States of America) and thus more direct methods such as interviews would have been impossible;
3. the number of questionnaire items was rather large and again personal interviews would not have been possible; and
4. the nature of the data required statistical analysis, which would have not be possible within qualitative means.

The use of case studies became necessary because:

1. case studies allow for an analysis of each organization as to the questions of what, how and why;
2. since the researcher had no control over any of the organizations or the comments employees provided, case studies were the most appropriate method;
3. case studies provide a realistic depiction of the organization being studied which was a primarily goal of the research;
4. a case study is a comprehensive research method providing for added details of each of the organizations, and in this study, cases were used only for clarifying the mail survey responses of the organizations as to the topics being studies;
5. various phenomena can be explained through the use of examples which is a primary feature of a case study;
6. since the researcher usually has no clear indication of the study outcomes, case studies provide a more holistic view of the organization, making sure that the most important variables were not overlooked concerning the issues under review; and
7. case studies were needed to clarify, in more detail, the quantitative results of the survey questionnaire.

As described in section 1.6, certain precautions such as the instruction letter which was mailed with the questionnaire, the questionnaire mailed to participants' names and the assumption that the same individuals completed the questionnaire, were made to eliminate or reduce factors such as bias. Two groups of technical and non-technical administrators were participating in the study, each with their own views. It is possible that each group responded to survey items from their own biased perspective of how critical technological or financial issues were, for example. In other words, the participants' views probably do reflect their group membership and, thus affect their responses, resulting in biased results. Therefore, an equal number of both groups will be interviewed and the respondents' positions will be considered during interpretation of the data.

4.5 Selection of the Population

Consistent and positive perceptions among administrators' perception could provide strong justification for increasing support for technological change. Two groups of participants were included in the present research: (1) technical and (2) non-technical administrators in manufacturing. Any change such as manufacturing processes, improved product quality, or decreased time to market not only will have an impact on the manufacturing floor, but also will alter the activities of non-technical personnel, and in fact the organization's overall performance.

The population studied consisted of five hundred and fifty-four technical (i.e. engineering design, manufacturing and production, and quality engineering) and non-technical (i.e. sales/marketing, finance and accounting) administrators in two hundred and seventy-seven manufacturing organizations in the United States of America. These organizations were selected from the National Restaurant Association, 1994 Exhibit Guide and Program, which has the largest membership, and is the single most reliable source in North America, according to one of the executives of the largest food equipment manufacturer in the world. The size of the population made it appropriate to survey the entire population, rather than select a random sample. In addition to the mail survey, a number of cases were studied and are presented in Chapter 6.

The population represented a broad range of demographics in term of size, location, sales volume, number of employees and product line. A demographic representation of these organizations was presented in Chapter 1 and Appendix A.

Chapter 5

Empirical Research

5.1 Introduction

In Chapter 4, a description of research methodology was presented. This chapter describes the questionnaire, its validity and reliability, procedures for data collection and analysis. It then presents the findings of the empirical mail survey.

5.2 Questionnaire, Content Validity and Reliability

To meet the objectives of the study, a questionnaire was needed that provided both adequate coverage, and that could also indicate the consistencies of perceptions among the technical and non-technical administrators with respect to the benefits of group technology. Two questionnaires were identified in the literature. One was developed by Hyer and Wemmerlov and is currently used for commercial purposes (hence: the researcher was not able to obtain permission to use this questionnaire for the present research). The survey developed by Rathmill, Bruun and Leonard[1], also seemed appropriate and provided adequate coverage in all functional areas of the organization. Another option was to create a completely new questionnaire for the research. For the purpose of this research, the instrument developed by Rathmill, Bruun and Leonard was modified. Since the modified instrument was a new questionnaire, both the contents and construct validity and its reliability had to be demonstrated.

According to Borg and Gall (1983), content validity refers to the extent to which questionnaire items represent

1. Rathmill, K.; Bruun, P.; and Leonard R.; Total Company Appraisal for Group Technology. Personal communication with R. Leonard at the University of Manchester Institute of Science & Technology, and permission to use this material; August 11, 1994 and November 14, 1994.

the content area that the test will measure. Additionally, when a test or questionnaire is able to differentiate between different groups of people, construct validity of that questionnaire is established. They also defined construct validity as the extent to which a questionnaire will measure a theoretical construct.

A pilot questionnaire was mailed out on December 9, 1994 to a total of thirty-two (32) technical and non-technical individuals selected randomly from one manufacturer. They were asked to comment on: (1) the clarity of questionnaire items; (2) whether various functional areas had adequate coverage; and (3) any item that should have been added or deleted from the instrument.

The participants were asked not to answer any of the questions and simply return their comments on the content and coverage of the questionnaire items by December 16, 1994. It should be noted that this group of participants in the pilot study were not part of the actual mail survey nor the case study population. By December 21, 1994, only 15 (46.8%) had responded. A telephone follow up was made on December 22, 1994, to those who had not responded. This resulted in an additional 5 (15.6%) responses. On January 5, 1995, a third telephone follow up was made to the remaining members who had not yet responded. This third telephone follow up produced an additional 2 (%6.2) responses and by January 13, 1995, a total of 22 (%68.7) of 32 had responded.

The content of fourteen questionnaire items received participants' feedback. By modifying those content, the researcher established the questionnaire's content validity. Respondents' comments regarding the form of items and the resulting modifications established the construct validity of the questionnaire (Appendix C shows the original questionnaire and Appendix D the participants' comments).

According to Borg and Gall (1983), reliability is assessed by determining the extent to which a given measure is consistent, i.e. whether the measure is the same when taken the second time. In the present study, a coefficient of internal consistency, Cronback Coefficient Alpha (α) that is based on the average correlation of items, was used to establish the reliability of the questionnaire.

The data gathered from technical and non-technical participants was used to calculate the coefficient alpha (α) for every group: (1) responses from the design engineering group resulted in a coefficient of 0.96, (2) responses from the manufacturing and production engineering group resulted in a coefficient of 0.98, (3) responses from the financial and accounting group resulted in a coefficient of 0.99, and (4) responses from the the marketing and sales group resulted in a coefficient of 0.98. Measurement literature indicates that a reliability coefficient alpha (α) of 0.90 is achieved with proper construction of a measurement instrument (Ebel, 1979; Nunnally, 1967; Erickson and Wentling, 1976; and Helmstader, 1970). Since the coefficients of internal consistency achieved in this study ranged between 0.96 and 0.99, it was concluded that the questionnaire had sufficient reliability to warrant the comparison of means in an ANOVA procedure (Helmstader, 1970; and Kelley, 1927).

5.3 Procedures for Data Collection

A mail survey was used to measure the consistency of the perceptions of the population in this research about group technology. The mail survey covered two groups of participants. The questionnaire was organized to gain insights into perceptions without seeking open remarks from respondents to avoid possible inconsistencies in analyzing comments.

A letter describing the nature of the study, assuring the anonymity of each respondent, and stating a specific return date, was included with each survey instrument mailed to all individual participants in the study population (see Appendix E). In addition, each individual participant was provided a stamped, self-addressed envelope in which to return the completed survey. A total of thirty (30) respondents, from twenty-six companies, completed the survey and returned them by the date specified in the cover letter. A second mailing within one week after of the first due date was made to those who had not responded and resulted in an additional ninety-nine (99) respondents, from twenty-four companies. This provided a response rate of 23.3% from individuals and 18.1% from companies. A summary of the response rate is shown in Figure 5.1. A reasonable number of responses had been gathered to conduct the analysis, and there are no known characteristics which would differentiate respondents from non-respondents.

5.4 Procedures for Data Analysis

Before proceeding to data analysis of this research, it is important to briefly review the literature on different statistical procedures.

According to Levin and Fox (1988), Borg and Gall (1983), Summers, Peters, and Armstrong (1981), and Edwards (1960), there are a number of statistical procedures that are applied to various problems in research. Some are used for determining whether sample differences are statistically significant or not. Others were developed to determine the degree of association between variables.

Figure 5.1

Response Rate Analysis

Number of companies in study	277
Number of technical members in study	554
Number of nontechnical members in study	554

		% of technical responded	% of nontechnical responded	% of Companies responded
First mailing:				
Companies responded	26			9.386281588
Tech. responded, usable	12	2.166064982		
Tech. responded, unusable	4	0.722021661		
Non-tech. responded, usable	10		1.805054152	
Non-tech. responded, unusable	4		0.722021661	
Total		2.888086643	2.527075812	9.386281588
Second mailing:				
Companies responded	24			8.664259928
Tech. responded, usable	52	9.386281588		
Tech. responded, unusable	2	0.361010830		
Non-tech. responded, usable	41		7.400722022	
Non-tech. responded, unusable	4		0.722021661	
Total		9.747292419	8.122743682	8.644259928
Combined total		12.635737906	10.64981949	18.05054152

Note: There are fifty companies, in total, that have responded. There are no responses from either the technical or non-technical group from eight companies. There are responses from another eight companies that are single response. There are at least one technical and one nontechnical response from all other companies. There are no responses at all from any of the Canadian companies.

Borg and Gall (1983) have classified these statistical procedures and techniques into three categories:

1. Descriptive statistics techniques: as the name illustrates, these measure the central tendency and variability, among others, that is helpful in evaluating data collected on a single variable. The mean, median, and standard deviation are the main descriptive statistics used to indicate the average score and the variability of scores for the sample. Correlational statistics, on the other hand, are used to describe the relationship between two or more variables. The advantage of this type is that they enable one to use, for example, the mean and standard deviation to represent all the individual scores of subjects in the sample. However, some descriptive statistics greatly simplify the task of data interpretation while limiting one's understanding.
2. Test statistics techniques: these are a set of specialized tools and mathematical methods for analyzing the extent to which a particular test is a good measuring instrument.
3. Inferential statistics techniques: these are used to make inferences from sample statistics to the population parameters. These mathematical procedures are used for determining whether the scores collected from a sample of research subjects are representative of the scores that would have been obtained if the entire population had been observed. It should be noted that descriptive values (i.e.: mean, median, and standard deviation) obtained by computing the scores of a sample of subjects are referred to as

'statistics'. These same values are called parameters when computed from the scores of the entire population.

An appropriate statistical procedure must be identified since different procedures require that the data be collected in different forms. Moreover, each procedure has a set of assumptions for its application. Levin and Fox (1988, pp. 390-391), explain that in selecting from among many procedures, one must consider a number of factors such as:

> "1. Whether the researcher seeks to test for statistically significant differences, degree of association, or both;
> 2. Whether the researcher has achieved the nominal, ordinal, or interval level of measurement of the variables being studied,
> 3. Whether or not the variables being studied are normally distributed in the population from which they were drawn, and
> 4. Whether the researcher is investigating independent samples or the same sample measured more than once."

Table 5.1 shows some procedures with respect to the key assumptions that must be considered for application.

A clear explanation of the levels of measurements (Table 5.1, Nominal, Ordinal and Interval) are also needed so that they will take on substantial meaning when the researcher attempts to apply a particular statistical technique to this particular situation.

The nominal level of measurement merely encompasses the process of labeling or placing data into categories and calculating their frequency of occurrence such as sex (male vs. female). It is important to keep in mind that every data point must be placed in one category only. The categories must be exclusive and therefore the data is not ranked for qualities. When the research expands beyond this

Table 5.1
Selecting an appropriate statistical procedure

Level of measurement	Independent samples	Same sample measured twice	Correlation
Nominal	Chi-Square		Phi coefficient, Contingency, Cramer's *V*, and lambda
Ordinal	Median test, Kruskal-Wallis one-way analysis of variance	Friedman two-way analysis of variance	Spearman's rank-order, Goodman's and Kruskal's gamma
Interval	t ratio, Analysis of Variance	t ratio	Pearson's r

From Elementary Statistics in Social Research, fourth edition,
by Levin, J. and Fox J. A. (1988), p. 391.
Published by Harper & Row, Publishers, New York.

simple measurement, the ordinal level is used. The ordinal level examines the data in terms of the scope the researcher has identified them. However, because the intervals between the data points are not known in this system, it provides little meaningful information. By contrast the interval level of measurement uses constant units of measurement, it not only reveals to the researcher the distribution of categories, but also signifies the precise span between them (Levin and Fox, 1988).

To illustrate the interpretation of data collected, a statistical procedure should hold the type I error (rejecting the null hypothesis when it should have been accepted) at a fixed level by establishing a comparison as to whether the variation between the sample means is greater than the difference found between the group overall.

The fundamental analysis in this study is composed of three comparisons: technical vs. non-technical administrators' perceptions, comparison of technical administrators' perceptions among themselves and comparison of non-technical administrators' perceptions among their own group.

The paired 'T' test is preferred when the two groups are considered dependent. While each group by itself can be considered dependent in a 'within group' analysis, an overall method was needed to allow for the same type of analysis of the three comparisons made. Thus, a test comparing the variance found within and between these groups was needed because of the following reasons:

1. their functional responsibilities are separated from each other within the organization;
2. they are supervised and accountable to different entities within the organization;

3. the educational background varies largely between the two groups, i.e. technical administrators are primarily trained engineers where as the non-technical administrators are typically business graduates; and
4. their professional experiences are distinct from each other.

While the intra comparison among technical or non-technical administrators could be considered dependent, the researcher sought to use one tool for all three major comparisons to ensure maximum consistency of results.

The procedure known as the Analysis of Variance (ANOVA) seeks to measure the differences between two independent groups. Since we have established that the two groups in this study were independent, the ANOVA procedure is the most viable statistical tool, which can be used. Levin and Fox explain the logic of ANOVA as:

> "In conducting an analysis of variance, we treat the total variation in a set of scores as being divisible into two components: the distance of raw scores from their group mean known as variation within group and the distance or deviation of group means from one another referred to as variation between groups." (Levin and Fox, 1988, p. 241)

The analysis of variance also generates an *F*-ratio in which all differences between groups and differences within groups are compared. ANOVA, in short, is a statistical test which makes a single overall decision as to whether a significant difference is present or not. The greater the *F*-ratio, the larger the probability of rejecting the null hypothesis and accepting the research hypothesis (Levin and Fox, 1988, and Summers, Peters, and Armstrong, 1981).

The question in this research was to find whether there was any significant difference between the technical and non-technical administrators' perception toward group technology, and since ANOVA generated this overall comparison, it was used to determine if there was any difference. However, the perception that a relationship exists does not convey much about the degree of correlation between the variables. Various relationships are statistically significant; however, few represent the ideal correlation. Correlation can frequently be articulated with respect to direction as either positive or negative.

A positive correlation expresses the fact that respondents getting high scores on the X variable also tend to get high scores on the Y variable. Conversely, respondents who get low scores on the X also tend to get low scores on Y. A negative correlation, on the other hand, occurs if respondents who obtain high scores on the X variable tend to obtain low scores on the Y variable. Conversely, respondents achieving low scores on X tend to achieve high scores on Y (Levin and Fox, 1988).

For the purposes of this research two correlational procedures, Cronbach and Pearson, were employed to analyze questionnaires and the data collected. These were:

Cronbach procedure: Cronbach's alpha (α) has various meanings. It can be looked at as the correlation between this test (or scale), and all other possible tests (or scales) containing the same number of items, which could be composed from a theoretical universe of items that measure the attribute of interest. Another understanding of Cronbach's (α) is the squared correlation between the score a person obtains on a specific scale (the observed score), and the score he or she would have obtained if questioned on all the possible items in the universe (the true score). Since alpha is accepted as a correlation coefficient, it ranges in value from zero (0) to one (1).

The standardized item α is the value that would be obtained if all of the items were standardized to have a variance of one (1). When items are standardized to have the same variance, the Cronbach's α can be computed using the following formula:

$$\alpha = (k\ r) \ / \ [1 + (k - 1)\ r]$$

Where k is the number of items in the scale and r is the average correlation between items (Norusis[1]).

Pearson procedures: Pearson's correlation coefficient (r) is a correlation coefficient for interval data. Pearson's r gives an effective measure of the strength and direction of the correlation in the sample being studied. The Pearson's correlation coefficient devotes not only a measure of the relationship between variables, but also an index of the ratio of individual differences in one variable that can be related with the individual differences in another variable. With the support of Pearson's correlation coefficient r, the strength and the direction of the relationship between variables that have been measured at the interval levels is examined. The quantity of r is the product of the X and Y deviations from their respective means. Pearson's r yields a precise gauge of the strength and direction of the correlation in the sample studied.

The Pearson's r can be computed using the following formula (Levin and Fox, 1988[2]):

$$r = [\Sigma X\ Y - N\ (\overline{X})\ (\overline{Y})] \ / \ \{[\Sigma (X)\text{^}2 - N\ (\overline{X})\text{^}2] \\ [\Sigma\ (Y)\text{^}2 - N(\overline{Y})\text{^}2]\}\text{^}0.5$$

1. From SPSS Base System User's Guide (P.467)
2. From Elementary Statistics in Social Research (p. 316)

The research hypotheses to be investigated were:

1. There is no statistically significant difference between the technical and the non-technical administrators' perceptions towards the benefits of group technology.
2. There is no statistically significant difference within the non-technical administrators' perceptions towards the benefits of group technology.
3. There is no statistically significant difference within the technical administrators' perceptions towards the benefits of group technology.

Every questionnaire item essentially represented a potential benefit of group technology and the research sought to determine respondents' perception regarding those benefits.

Statistical hypotheses for the study were constructed for each variable and were stated as a null hypothesis. An ANOVA yielding an *F*-ratio was conducted in order to determine if there were significant differences or similarities in the ratings at 0.05 level of probability (Spatz and Johnston, 1989). A *Pr* value associated with an *F*-ratio of less than 0.05 determines rejection of the null hypothesis. The 0.05 level of significance was cited by Isaac and Michael (1981), as being the accepted convention in research. This is due to the fact that 0.05 level of significance reduces the probability of rejecting the null when it is correct. Type I errors (Spatz and Johnston, 1989). Type I errors occur when a true null hypothesis is rejected when it should have been accepted. Type III SS calculates the reduction in error SS by adding the effect after all other effects are adjusted. In other words, sum of squares is referred to as Type III SS where it is adjusted for all other variables (means square = sum of squares/number of degrees of freedom). In this case, since the number of degrees of freedom is one, Type III SS and mean squares are the same.

The instrument used in the mail survey was developed to acquire awareness into perceptions without exploring open comments from respondents to avoid probable disagreements in analyzing remarks.

5.5 Findings

As was stated, the data were analyzed and the research hypothesis was tested using the ANOVA procedure. Summary ANOVA tables were constructed with sum of squares, means squares, *F* values and P>*F*.

Hypothesis Number 1:

> There is no statistically significant difference between the technical and non-technical administrators' perceptions of the benefits of group technology.
>
> H_O: Means of technical and non-technical administrators are the same for every questionnaire item (alpha = 0.05).
>
> H_A: Not all means are the same.

The first hypothesis was tested by ANOVA to determine any significant difference between the technical and non-technical administrators' perceptions. ANOVA was employed to determine the significance for every questionnaire item when comparing the responses of technical and non-technical administrators's perceptions to group technology. Results of the ANOVA on all items, comparing mean responses of the technical and non-technical administrators, are shown in

Appendix F. A score of '1' indicates a strong agreement, whereas a score of '5' indicates a strong disagreement. The research found a significant difference between the means of technical and non-technical administrators responses as shown in Appendix F. Responses to all questionnaire items proved significantly different at 0.05 level of probability. Therefore, the research rejects the null hypothesis. This means that the technical and non-technical administrators did not perceive the benefits of group technology similarly. The summary of the technical vs. non-technical administrators' perceptions from the ANOVA suggests that the two means are significantly different (the *P* value is less than 0.05).

A review of the results indicates that the two groups had the largest difference in the areas of production planning (questionnaire items 27, 28, and 29); and management function (questionnaire items 44 and 45).

The second and third hypotheses were tested to determine the homogeneity of each group.

Hypothesis Number 2:

> There is no statistically significant difference within the non-technical administrators' perceptions of the benefits of group technology.
>
> H_O: Means of each of the non-technical administrators is the same for every questionnaire item (alpha = 0.05)
>
> H_A: Not all means are the same.

The second hypothesis was also tested by ANOVA to determine any significant difference between the technical and non-technical administrators' perceptions. ANOVA was employed to determine the significance for every questionnaire item when comparing the responses of non-technical administrators's perceptions to group technology. Results of the ANOVA on all items, comparing mean responses of the non-technical administrators, are shown in Appendix G. A score of '1' indicates a strong agreement whereas a score of '5' indicates a strong disagreement. The research has found no significant difference between the means of non-technical administrators' responses. Responses to all questionnaire items proved significantly similar at 0.05 level. Therefore, the research failed to reject the null hypothesis. This means that the non-technical administrators did perceive the benefits of group technology in the same way. A review of the results indicates that this group had the largest similarity in the areas of design and planning engineering (questionnaire items 7, 14 and 19).

Hypothesis Number 3:

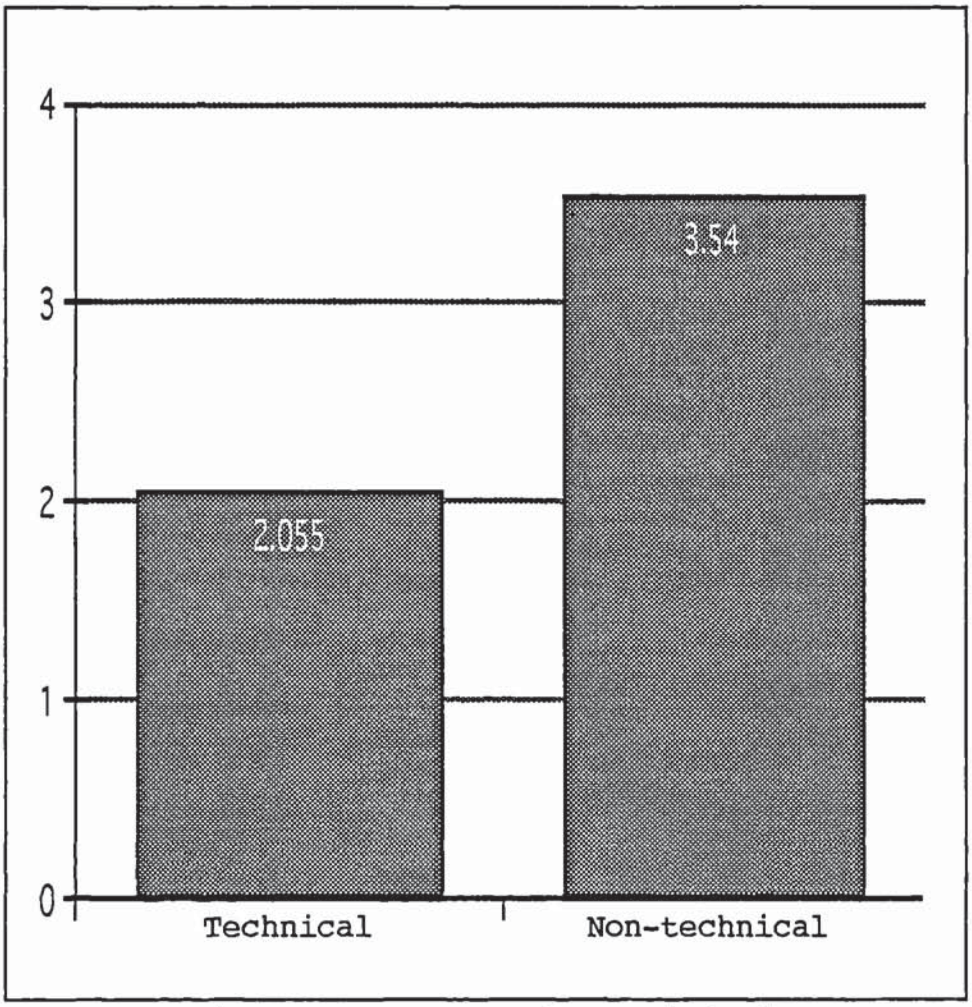
> There is no statistically significant difference within the technical administrators' perceptions of the benefits of group technology.
>
> H_O: Means of each of the technical administrators is the same for every questionnaire item (alpha = 0.05)
>
> H_A: Not all means are the same.

The third hypothesis was also tested by ANOVA to determine any significant difference between the technical and non-technical administrators' perceptions. ANOVA was employed to determine the significance for every questionnaire item when comparing the responses of technical administrators's perceptions to group technology. Results of the ANOVA on all items, comparing mean responses of the technical administrators, are shown in Appendix H. A score of '1' indicates a strong agreement whereas a score of '5' indicates a strong disagreement. The research has found no significant difference between the means of the technical administrators' responses. Responses to all questionnaire items proved significantly similar at 0.05 level of probability. Therefore, the research failed to reject the null hypothesis. This means that the technical administrators did perceive the benefits of group technology similarly.

A review of the results indicates that this group had the largest similarity in the areas of production planning, reduction in inventory, work-in-progress, absenteeism and labor turn-over (questionnaire items 30, 31 and 32).

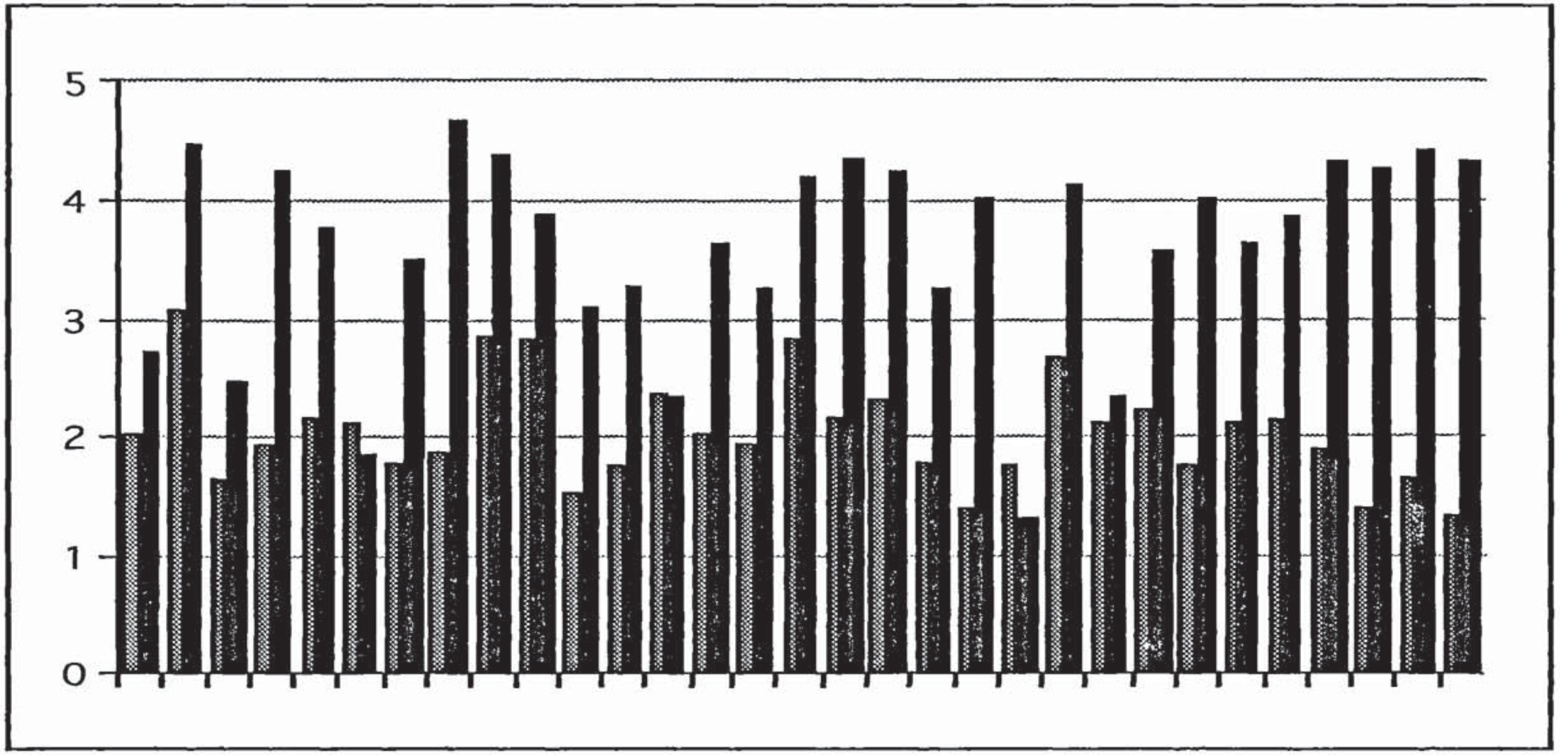
These findings are illustrated in Figures 5.2 and 5.3, where Figure 5.2 is based on the scores of the technical vs. non-technical administrators' responses (interorganization), and Figure 5.3 is based on the scores of those multiple responses of the same organizations (intra-organization).

Figure 5.2
Interorganization Average scores
Technical vs Non-Technical
Admininstrators



The average score for technical
group is 2.055 and it is 3.540 for
the non-technical group

Figure 5.3
Intera-Organization Average Score
Technical vs Non-Technical Groups



The mail survey questionnaire, in this research, was mainly divided into functional areas such that adequate coverage was given to individual departments in the organization. A summary of the results of the ANOVA analysis was presented. It stated that there exists a statistically significant difference between the technical and non-technical administrators' perceptions towards group technology.

A review and summary of the ANOVA and Pearson's Correlation Coefficient (Tables 5.2 through 5.10) is presented that will provide additional support for this finding (hence: based on the results of the analysis, correlation coefficients for technical and non-technical administrators' within groups are inversely related). The Pearson correlation *r* ranges between -1 and +1, where *r* values closer to +1 are correlated strongly (in agreement) and where *r* values closer to -1 are also correlated strongly (in disagreement). In other words, both *r* values indicated strong correlation - therefore, a high degree of correlation, whether the respondents mostly agree or mostly disagree.

In this study it was important to determine a high correlation among the responses of each technical and non-technical group, because high correlation would provide for increased consistency among the results.

This research, through case studies of selected industries, elicited comments from both questionnaire respondents and others to allow the inclusion of possible perceptions of respondents which were not included in the questionnaire. The researcher's purpose was to use the perspective derived from the empirical mail survey analysis and synthesis of the case studies (Chapter 6) to develop conclusions presented in Chapter 7.

Table 5.2
A Comparison of Results
Production Engineering Function

Questionnaire Item	ANOVA Tech. vs. Non-Tech. F Value	ANOVA Tech. F Value	ANOVA Non-Tech. F Value	Correlation α Tech. (D/M)	Correlation α Non-Tech. (F/K)
1	58.87	0.00	0.00	0.960/0.980	0.990/0.988
2	65.49	0.00	0.02	0.960/0.981	0.990/0.988
3	71.64	0.49	0.21	0.960/0.980	0.990/0.988
4	52.39	0.24	0.31	0.959/0.980	0.990/0.988
5	66.12	0.00	0.65	0.960/0.980	0.990/0.988
6	57.23	0.02	0.17	0.959/0.980	0.990/0.988
7	74.33	0.02	1.75	0.959/0.980	0.990/0.988
8	59.25	0.28	0.78	0.959/0.980	0.990/0.988
9	59.54	0.44	0.06	0.959/0.980	0.990/0.988
10	53.29	1.71	0.45	0.960/0.981	0.990/0.988
11	40.11	0.85	0.19	0.961/0.980	0.990/0.988
12	45.57	1.95	0.25	0.960/0.981	0.990/0.988

NOTE: Correlation α (D/M) = Design/Manufacturing Groups and (F/K) = Finance/Marketing Groups

Table 5.3
A Comparison of Results
Design Engineering Function

Questionnaire Item	ANOVA Tech. vs. Non-Tech. F Value	ANOVA Tech. F Value	ANOVA Non-Tech. F Value	Correlation α Tech. (D/M)	Correlation α Non-Tech. (F/K)
13	46.28	0.95	0.05	0.960/0.980	0.990/0.988
14	66.04	0.09	1.38	0.960/0.980	0.990/0.988
15	64.94	0.38	0.21	0.960/0.980	0.990/0.988
16	74.58	0.00	0.24	0.959/0.980	0.990/0.988
17	80.60	0.70	1.22	0.959/0.980	0.990/0.988
18	47.81	0.02	0.13	0.959/0.980	0.990/0.988
19	50.70	0.10	2.22	0.960/0.980	0.990/0.988

Table 5.4
A Comparison of Results
Quality Engineering Function

Questionnaire Item	ANOVA Tech. vs. Non-Tech. F Value	ANOVA Tech. F Value	ANOVA Non-Tech. F Value	Correlation α Tech. (D/M)	Correlation α Non-Tech. (F/K)
20	74.37	0.71	0.00	0.959/0.980	0.990/0.988
21	48.56	0.11	0.05	0.960/0.980	0.990/0.988
22	58.53	0.00	0.34	0.960/0.981	0.990/0.988

NOTE: Correlation α (D/M) = Design/Manufacturing Groups and (F/K) = Finance/Marketing Groups

Table 5.5
A Comparison of Results
Purchasing and Buying Function

Questionnaire Item	ANOVA Tech. vs. Non-Tech. F Value	ANOVA Tech. F Value	ANOVA Non-Tech. F Value	Correlation α Tech. (D/M)	Correlation α Non-Tech. (F/K)
23	44.64	1.71	0.06	0.962/0.981	0.990/0.988
24	33.59	2.08	0.27	0.961/0.980	0.990/0.989

Table 5.6
A Comparison of Results
Finance Function

Questionnaire Item	ANOVA Tech. vs. Non-Tech. F Value	ANOVA Tech. F Value	ANOVA Non-Tech. F Value	Correlation α Tech. (D/M)	Correlation α Non-Tech. (F/K)
25	53.37	0.00	0.06	0.960/0.980	0.990/0.988
26	78.87	0.09	0.06	0.960/0.980	0.990/0.988

NOTE: Correlation α (D/M) = Design/Manufacturing Groups and (F/K) = Finance/Marketing Groups

Table 5.7
A Comparison of Results
Production Planning and Stock Control Function

Questionnaire Item	ANOVA Tech. vs. Non-Tech. F Value	ANOVA Tech. F Value	ANOVA Non-Tech. F Value	Correlation α Tech. (D/M)	Correlation α Non-Tech. (F/K)
27	103.87	0.02	0.21	0.959/0.980	0.990/0.988
28	97.66	2.08	0.71	0.959/0.980	0.990/0.988
29	86.80	0.09	0.31	0.958/0.980	0.990/0.988
30	62.37	1.48	1.00	0.959/0.980	0.990/0.988
31	60.38	2.51	1.00	0.959/0.980	0.990/0.988
32	57.57	3.39	1.16	0.959/0.980	0.990/0.988
33	80.09	0.96	0.08	0.959/0.980	0.990/0.988
34	63.12	0.02	0.13	0.960/0.980	0.990/0.988

Table 5.8
A Comparison of Results
Direct Labor Function

Questionnaire Item	ANOVA Tech. vs. Non-Tech. F Value	ANOVA Tech. F Value	ANOVA Non-Tech. F Value	Correlation α Tech. (D/M)	Correlation α Non-Tech. (F/K)
35	64.67	1.99	0.17	0.959/0.980	0.990/0.989
36	61.20	1.30	0.07	0.960/0.980	0.990/0.988
37	57.38	4.63	1.00	0.960/0.980	0.990/0.989
38	19.13	0.27	0.06	0.961/0.981	0.990/0.989

NOTE: Correlation α (D/M) = Design/Manufacturing Groups and (F/K) = Finance/Marketing Groups

Table 5.9
A Comparison of Results
Marketing and Sales Function

Questionnaire Item	ANOVA Tech. vs. Non-Tech. F Value	ANOVA Tech. F Value	ANOVA Non-Tech. F Value	Correlation α Tech. (D/M)	Correlation α Non-Tech. (F/K)
39	65.17	0.86	1.32	0.960/0.981	0.990/0.988
40	74.88	2.84	1.44	0.960/0.980	0.990/0.988
41	81.07	1.40	0.65	0.960/0.980	0.990/0.988

Table 5.10
A Comparison of Results
Management Function

Questionnaire Item	ANOVA Tech. vs. Non-Tech. F Value	ANOVA Tech. F Value	ANOVA Non-Tech. F Value	Correlation α Tech. (D/M)	Correlation α Non-Tech.(F/K)
42	85.28	0.00	0.05	0.959/0.980	0.990/0.988
43	66.32	1.85	2.22	0.959/0.980	0.990/0.988
44	93.27	0.08	0.07	0.959/0.980	0.990/0.988
45	86.84	0.74	0.31	0.959/0.980	0.990/0.988
46	43.91	1.06	0.31	0.960/0.981	0.990/0.988
47A	48.52	0.52	1.00	0.960/0.981	0.990/0.988
47B	74.74	0.06	0.85	0.961/0.980	0.990/0.988
47C	76.03	0.11	1.81	0.961/0.980	0.990/0.988
47D	70.22	0.72	0.03	0.962/0.980	0.990/0.988

NOTE: Correlation α (D/M) = Design/Manufacturing Groups and (F/K) = Finance/Marketing Groups

CHAPTER 6

CASE STUDIES

6.1 Introduction

This research was designed to examine the consistency of technical and non-technical administrators' perceptions towards the benefits of group technology in the food equipment manufacturing organizations in the United States. As was discussed earlier in Chapter 4, in addition to experiments and survey methods, the case study is one of the many ways to conduct research. Presented in this chapter are the organizations that participated in the case study analysis. These included a total of six (6) manufacturing organizations: two from the food equipment and preparation industry, two from the electronics industry, and two from the traditional mechanical industry. In addition to the food equipment companies, the mechanical and electronics manufacturers were selected because the food equipment industry, in the production of their equipment, uses both mechanical systems (gear drives) as well as electronics.

6.2 Purpose of Case Studies

There have been many applications of group technology philosophies in all areas of company operations from design to manufacturing, and it is possible to identify common characteristics among different companies. The early development of group technology was concerned with the grouping of parts to rationalize hard tooling and to reduce set-up times. Subsequent developments included the development of cellular layout, design retrieval, and variety reduction. Later development in West Germany and the USA focused on the use of GT principles for the development of scientific and computer-aided procedures.

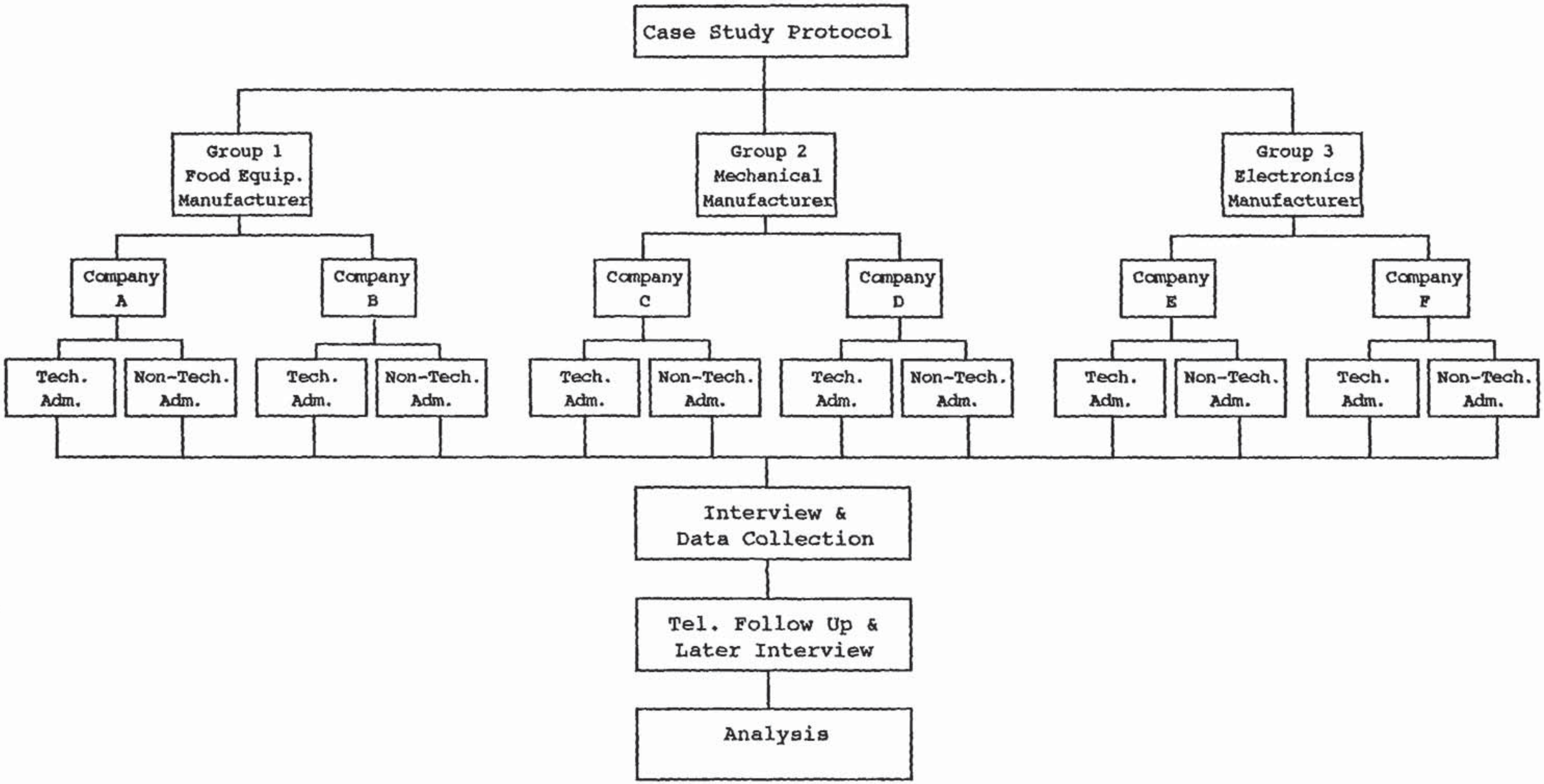
The questionnaire used in the mail survey was organized to gain insight into perceptions without seeking open responses from respondents to avoid possible difficulties in data analysis. Therefore, research through case studies of industries identified earlier, solicited comments both from questionnaire respondents and others to allow the inclusion of perceptions of respondents which were not included in the mail survey questionnaire. This was accomplished through a review of the statistical results of the mail survey, and was then followed by open personal interviews during the months of April/May of 1996, December 1997, and January/February 1998, with technical and non-technical administrators from each of the organizations.

The purpose and inclusion of these companies was to not only broaden the scope of the research, but also gain insights into perceptions regarding group technology and the management of technological change in general.

As stated earlier in Chapter 4, the research methodology included the empirical analysis as well as case studies that are the favored strategy when "how" or "why" questions are being posed. According to Hamel (1992) and Perry and Kramer (1986), case studies are increasingly used as a research tool that promotes the understanding of the social phenomena such as psychology, political science, and business and planning (Yin, 1993). The design of the protocol of these cases (Figure 6.1) was based on the results of the mail survey and review of literature. A list of statements was prepared for the purposes of the case study data collection. Mail survey questionnaire items were grouped into broad functional topics providing for the topics addressed in the case studies:

A. Issues related to group technology and its reported benefits (1 through 8 below) were:

Figure 6.1


Case Study Protocol
Group 1 Food Equip. Manufacturer
Group 2 Mechanical Manufacturer
Group 3 Electronics Manufacturer
Company A
Company B
Company C
Company D
Company E
Company F
Tech. Adm.
Non-Tech. Adm.
Interview & Data Collection
Tel. Follow Up & Later Interview
Analysis

1. GT improves production-engineering activities.
2. GT improves design-engineering activities.
3. GT improves quality-engineering activities.
4. GT improves purchasing and buying activities.
5. GT improves production-planning and stock control activities.
6. GT improves direct labor activities.
7. GT improves marketing and sales activities.
8. GT improves management activities.

B. Issues related to management and technological change in general (9 through 19 below) were:

9. When Advanced Manufacturing Technology (AMT) is justified on the basis of a strict financial analysis, its potential is never achieved, because:
   A. Managers confuse AMT with traditional automation. They perceive its primary benefits as direct labor savings rather than strategic capability enhancement.
   B. Organized labor sees AMT as a threat to job security & resists its implementation.
   C. AMT is not justified on the basis of all factors, and the company is deprived of important assets.
10. There is a great deal of agreement among American managers that a short-term orientation exists at the expense of longer-range issues.
11. In justifying AMT, production-engineering personnel believe that AMT is the wave of the future, and they include strategic as well as financial factor considerations in appropriation decisions.

12. In justifying AMT, financial personnel noting that AMT requires larger investment and has a higher operating cost are mainly concerned with its financial considerations.
13. The present educational system reinforces the lack of system awareness by teaching subjects such as manufacturing processes and production management in isolation from one another.
14. The educational system, in statement 13, is repeated in career structures where the decision to follow a particular path is often taken at a rather young age and the progression is along that career path where logic is not so much need-driven as traditional founded and historically reinforced. Thus the engineer is an engineer and is normally trained in a rather narrow specialized domain. In similar fashion, non-technical personnel are unlikely to have an ongoing commitment to any other functional areas.
15. The staff in a majority of companies is composed of people whose education, training and experience is often discipline-based and thereby not well suited to taking an overall view of the business.
16. Marketing inertia can lead to organizational rigidity in reacting to change.
17. The competitive strategy is solely the domain of finance and marketing.
18. Anticipated AMT decisions are related to a desire to increase profitability, but are constrained by start-up performance

difficulties sometimes associated with AMT.

19. It is important to industry that technical and non-technical personnel should combine their effort in an environment, which assists with the simplification of the tasks of both parties.

C. Although the list of statements was focused, the interviews themselves were of the open-ended type. The participants were given the opportunity to respond to each statement, and also add their unique perceptions about the phenomenon of change and implementation.

D. In order to allow for a common comparison between questionnaire and case studies, responses to case study statements were coded similar to that of the mail survey questionnaire (1=Strongly Agree, 2=Agree, 3=Neutral, 4=Disagree and 5=Strongly Disagree). The data collected was analyzed using the 'T' test mentioned earlier in this section.

Analysis of these cases included both quantitative analysis (similar to the mail survey questionnaire) as well as open discussion and information provided by the participants in regards to the broad functions, and in particular, management functions were discussed in more detail.

Case studies in general provide for a meaningful view of the organization. However, in this research, cases were used to confirm the results obtained from mail survey analysis and in providing additional insight into these organization. Participants, unless otherwise stated, in these cases had requested, and felt very strongly, that both the organization and their individual identities be withheld due to commercial and personal reasons.

6.3 Case Studies: Participating Organizations

6.3.1 Group 1: Food Equipment Industry, Company A

Two interviews were conducted, one with a non-technical administrator (a Vice President) and one with a technical administrators (a Senior Manufacturing Engineer). The interview was with the vice president and the general manager of one of the divisions, who has extensive knowledge and experience in international sales and marketing. This company is an internationally known market leader and is a division of a larger corporation. The company designs, manufactures, and markets a number of products under various brand names to both retail and service industries. This firm is mainly structured into five product groups or profit centers, according to the senior vice president. These include:

1. Food Machines division: with such products as meat slicers, meat grinders, mixers and food processors, among others, and is the largest division in the organization.
2. Cooking division: is responsible for such products as convection ovens, fryers and deep fryers, microwave ovens, griddles, and other similar products.
3. Refrigeration division: manufactures stand-alone as well as walk-in refrigeration units in a number of different sizes to meet the market demand.
4. Warewash division: manufactures various dishwashers and waste processing equipments that are mainly used in restaurants and other large institutions such as schools.
5. Weigh/Wrap division: is responsible for the weighing and wrapping equipment mainly used in

super markets. In addition, small cash register machines, used in super markets, are produced by this division.

The company has six thousand (6000) employees worldwide, and estimated annual corporate sales of 1.2 billion dollars in 1994. The number of personnel in manufacturing is about one third of the total employees, or two thousand (2000). The company has a number of manufacturing facilities both in North and South America, Europe, and the Far East, totaling about one million square feet. Additionally, they sell a large number of custom made products and different accessories, of which 80% are manufactured by the company. The majority of the manufacturing activities are centered on machining and fabrication (about 80%) and the remaining 20% is devoted to sub and final assembly. The company's staff are both union and non-union.

Mr. Shariff, a senior manufacturing engineer, provided a plant tour where two manufacturing cells have been in operation for a few years. These were a gear cutting cell and a shaft cell. The gear cell consisted of turning, hobbing, grinding, generator (for bevel gears), deburing, broaching machines, and an inspection section. Figure 6.2, the raw materials, in form of bar stock, castings, or forgings, enter the gear cell and follow through according to the steps. It should be noted that the gears leave the cell for heat treatment and then return to the cell for subsequent finishing operations. Similarly, the shaft cell consist of turning, thread chasing, grinders, screw machines, milling, press, deburring machines, and an inspection station (Figure 6.3).

Figure 6.2
Gear Cutting Cell Layout
(Processes involved in manufacturing the particular part)

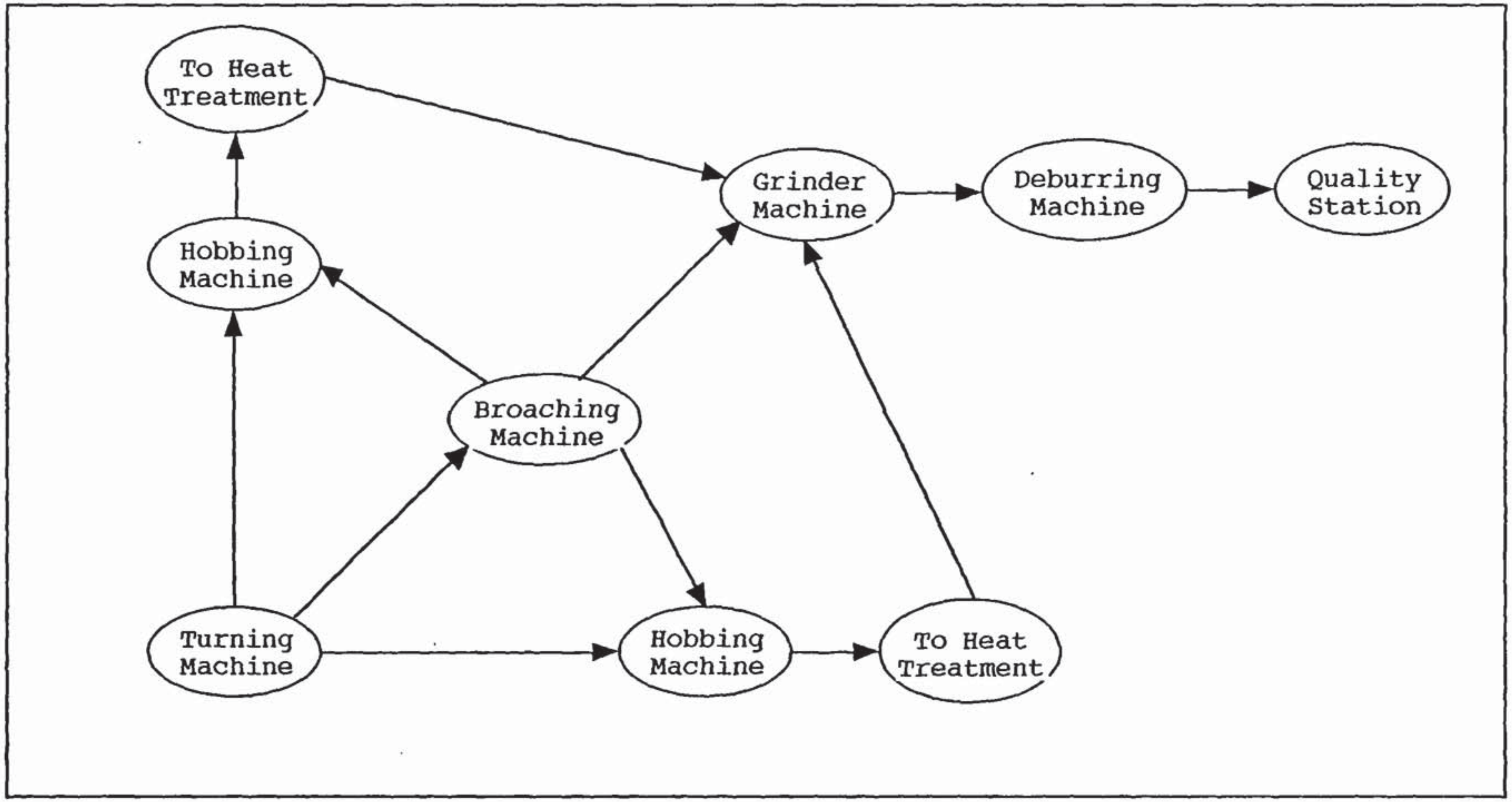
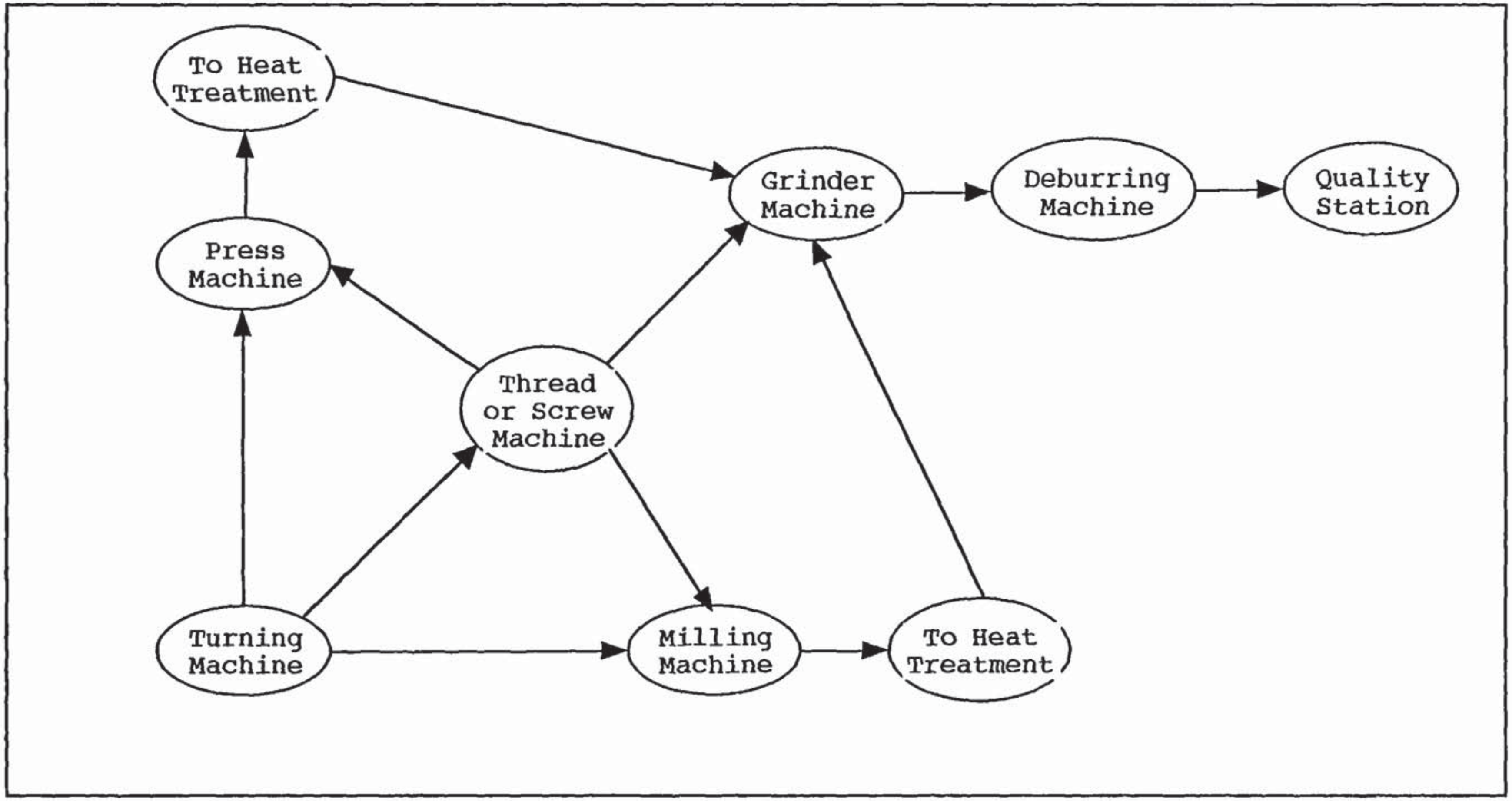


Figure 6.3
Shaft Cell layout
(Processes involved in manufacturing the particular part)



Most interesting, despite the gear and shaft cells, the Vice President claims that the company does not employ any of the group technology principles company wide, and has no plans to implement them. However, he believes that:

> "the company's structures are sufficiently flexible to be able to cope with the introduction of group technology or other advanced manufacturing technologies while stating that he believes that engineering wants what marketing and sales can not supply - a precise view of customers' needs. Technical and engineering personnel typically do not communicate in a language (financial resources needed for a particular project) that can be understood by other members of the organization.[1]"

In discussing the question of justification, the senior Vice President pointed out that justification on the basis of a strict financial analysis has been and "will continue to be acceptable." He proceeded to point to this process by indicating that the short-term orientation, practiced by many at the expense of longer-range issues "does not exist at the company he is with", and he does not agree with the statement of, "there is a great deal of agreement among American managers that a short-term orientation exists at the expense of longer-term issues". He asserts that in justifying implementation of group technology or any other Advanced Manufacturing Technologies (AMT), the technical personnel (manufacturing & production engineers) maintain that AMT is the wave of the future, and that they do not include financial factors, such as "return on investment and availability of funds, considered in appropriation decisions". Mr. Shariff, on the other hand, argued that "engineering personnel do include financial resources needed for a particular adoption. However, analysis performed by

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1. Vice President & General Manager, Troy, Ohio; April 12, 1996.

engineers, frequently, does not provide a clear 'bottom line' analysis, it does not often get the appropriation needed[1]". Mr. Shariff continued to say that there is an underlaying concept of "automation & improvement = job losses" from the shop floor employees' point of view and the organized labor unions.

The Vice President defended financial personnel, in justifying AMT, by noting that AMT requires a larger investment and has higher operating costs. He adds that "companies are composed of people whose education, training and experiences are often discipline-based", thus not well suited to taking an overall view of the business. He emphasizes that it is important to the industry that technical and financial personnel should combine their knowledge in an environment which assists with the simplification of the tasks of both parties. Mr. Shariff, in contrast, believes that the engineering personnel continuously work on the issue of value vs. cost, while the sales and marketing personnel depend solely on return on investment. He added that the "concept of excitement is new to most American marketing managers", referring to the auto industry, as an example, that needs to come up with new models more frequently than ever in the past. In fact, it is this concept that Mr. Shariff believes is taken into account as an insight to lay out various strategies needed for competing within the manufacturing function.

Group 1: Food Equipment Industry, Company B

The interview was held with the company's production manager. His education includes both manufacturing engineering and a graduate degree in business. He indicated that the company designs, manufactures and markets

1. Mr. Shariff, Sr. Mfg. Engineer, Troy, Ohio; January 9, 1998.

various items of electric and gas cooking equipment. The company also manufactures display cases under its own brand names. They are, along with the cooking equipments, marketed mainly to the service industry. The company employs four hundred and twenty-five (425) employees and had an estimated annual corporate sales of fifty-eight million dollars in 1994. About 70% of the employees are involved in manufacturing. The company's facilities total about 150,000 square feet. They produce a smaller range of products than company A. Roughly 35% of all products are manufactured in-house. Most of the manufacturing activities are centered on machining and fabrication (about 70%) and the remaining 30% are devoted to sub- and final assembling. The company staffs only non-union employees. At the present time, the company uses cellular manufacturing and believes that it's structures are sufficiently flexible to be able to cope with the introduction of any advanced manufacturing technologies.

The production manager agrees with both the mail survey results (statistical results) and the reported benefits of group technology in the literature that "group technology, implemented properly, could significantly and positively effect the entire operation[1]". He also has a different opinion than the senior vice president of company A on the issue of justification processes. He believes that a strict financial analysis will probably result in not achieving the full potential of the proposed technology. He feels that managers, "technical and financial, must evaluate the long-term effects of the technology rather than the short-term return on investment". However, he points out that "production engineering personnel need to become more familiar with financial consideration in preparing appropriation proposals." He also adds that financial

1. Production Manager, Dayton, Ohio; April 19, 1996 & Dec. 8, 1997.

administrators equally need to become more familiar with the potential benefits gained through proper implementation and utilization of technology. In today's global and competitive marketplace, he expressed "the need for people with a system (technical and business) understanding" that is not fulfilled by the present educational institutions.

6.3.2 Group 2: Electronic Industry, Company C

The interview was with the production manager. The company is a contract electronic assembly organization, and does not perform any design, except for limited in-house tooling and fixturing needs. The estimated corporate sales for 1994 were about twenty-four million dollars. The company has 180 employees in a non-union environment with 75,000 square feet devoted to manufacturing. The number of personnel in manufacturing accounts for over 80% of total employees. Since this is a contract electronics assembly facility, the company does not manufacture or fabricate any products (100% sub and final assemblies). The main activity of the company is to assemble electrical and electronic components onto circuit boards. They have a small number of products, about 250 different types, per customers' request. The manufacturing processes are separated into three essential stages of automatic components placement and soldering, manual component placement and soldering, and functional testing of final assembly, according to a line supervisor. In the first stage, all radial lead components were automatically placed onto the circuit board. They were then placed onto a conveyor which was part of the soldering station. These partially assembled circuit boards were then stacked up for the next stage of manual placement of axial components and assembly. It appeared there were backlogs on the shop floor as a result of individual orders imposing discrete work loads not only on each operation but perhaps each day. These adjustments, according to the production manager, originated because of order size, work-in-progress, and differences in complexity and different types of components.

However, there seemed to be other challenges including the oscillation of rush orders, rework activities, and some delays in processes awaiting delivery of, when required, special components. One major issue of production was of the growth of occurrence of changes and the need for adjusting activities due to the lack of ability to accurately estimate and plan work-in-progress, and it was not uncommon for employees to engage in other tasks. This, according to the production manager, had affected the growth (delay in increasing sales), which was the company's top objectives[1].

Nevertheless, according to the production manager, "the company had employed and was using cellular manufacturing and believed that the company structures were sufficiently flexible to be able to cope with the introduction of advanced manufacturing technologies[1]". However, based on detailed discussion with the production line supervisor, it became clear that the production manager was not familiar with cellular manufacturing systems and/or the advantages of group technology. The neutral opinion on almost every questionnaire item on the survey, by the production manager, confirmed this lack of knowledge about cellular manufacturing. He also had varied opinions on a number of other issues related to AMT. Most interestingly, and in contrast to the line supervisor's opinion, he felt that "the educational systems must reinforce specific subjects and believed that they should remain separated from other

1. Production Manager, Dayton, Ohio; April 26, 1996.

topics" so that individuals in particular functions are experts in their field. This was reinforced by his opinion that the "tasks of the technical and non-technical staff members are completely different and that their individual evaluation of adoption of new technology should be based on their field of expertise". He strongly suggested that if the financial analysis did not recommend the implementation of new technology, it should not be implemented. Hence, it is not clear based on observation and the production manager's response, if the company currently employs cellular manufacturing. It was very difficult to assess the rationale behind his opinion towards advanced manufacturing technologies. However, his opinion can perhaps be best summarized and compared with Skinner's (1985) point that:

> "Too many manufacturing managers focus on the short-term: meeting the monthly schedules, bogeys for quality and delivery, and labor/ personnel problem. They lack the strategic point of view... not seeing alternatives, and lacking the perspective of what is possible or even what other companies are doing, often in the same industry. Manufacturing strategy is a new art, often unknown." (Skinner, 1985, p. 145)

Group 2: Electronic Industry, Company D

The interview was a with the general manager. As with the previous company, this firm is also a contract electronic assembly organization and a competitor of company C in the same marketplace. The company is relatively new (about two or three years in operation). The general manager, formerly a sales account manager with company C, did not wish to share any of the personnel or financial data for the purposes of this research. However, based on previous visits to the company's facilities, it is estimated that they employ about one hundred people and are involved in manufacturing activities of mainly circuit board assemblies. Unlike company C, they perform limited sub-assembly production, utilizing the circuit board assemblies for their customers. The manufacturing processes can be best described as manual with minimal use of some semi-automated systems. The general manager had little knowledge of group technology or its potential benefits. He argues that there is a strong lack of system awareness in both our educational and business environments. He indicated that our higher educational institutions, in cooperation with industry, "must do much more to formulate new programs to help business stop the gap between theory and application."

He continued to explain the difficulties that manufacturing organizations, "smaller ones" he emphasizes, are faced with the financial institutions as well as other investors. He notes the "importance of return on investment for shareholders and the lending institutions as demanding high and risk free returns[1]".

6.3.3 Group 3: Mechanical Industry, Company E

This interview was with the production manager. The company designs, manufactures, and markets a number of heavy industrial mechanical products that are marketed to the ship building, oil field, automotive, & construction industries.

The company has about 1600 employees with estimated corporate sales of two hundred and ninety million dollars in 1994. About 75% (1,200) of the employees are involved in manufacturing, with a total of 600,000 square feet dedicated to this purpose. The company has five major and very specialized product lines, translating to one hundred and thirty-two different models. The company manufactures about forty percent of its needed parts. Component manufacturing,

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1. General Manager, Brookville, Ohio; May 3, 1996 and Feb. 20, 1998.

including machining and fabrication, accounts for 70% of all manufacturing activities with the remaining 30% devoted to sub and final assembly. The company is a non-union organization that currently is experimenting with group technology. The production manager believed that the company's structures are sufficiently flexible to be able to cope with the introduction of any advanced manufacturing technologies.

Although the company does not employ group technology, he recalled an experience in which he was personally involved with in the early-to-mid 1980s, at his previous employment. He asserted that the company was being challenged to reduce costs associated with the development and production of modern appliances. In his opinion, group technology offered significant possibilities for improving the productivity and procedural sameness of manufactured parts. Some of the important factors at the time included quality improvements, complex manufacturing processes, and training and retaining of a skilled workforce.

The products were made up of roughly 60 percent sheet metal that are of different geometric shapes. He recalled that a decision had been made to conduct an analysis to determine if an improved automated control and flexible manufacturing systems could be justified.

For the purposes of this analysis, part families were formed and correlated by another classification and coding system. The results were analyzed and then production operations were closely matched to this result. However, this had been all carried out within the manufacturing and production function and the company's procedures required a financial analysis. As part of the financial analysis, the manufacturing and production personnel had used computer simulation to provide relative performance of the proposed plan. In addition, a pilot study was performed as a special project, without moving any of the equipment. Based on the results of the pilot study, a number of benefits were identified. These included:

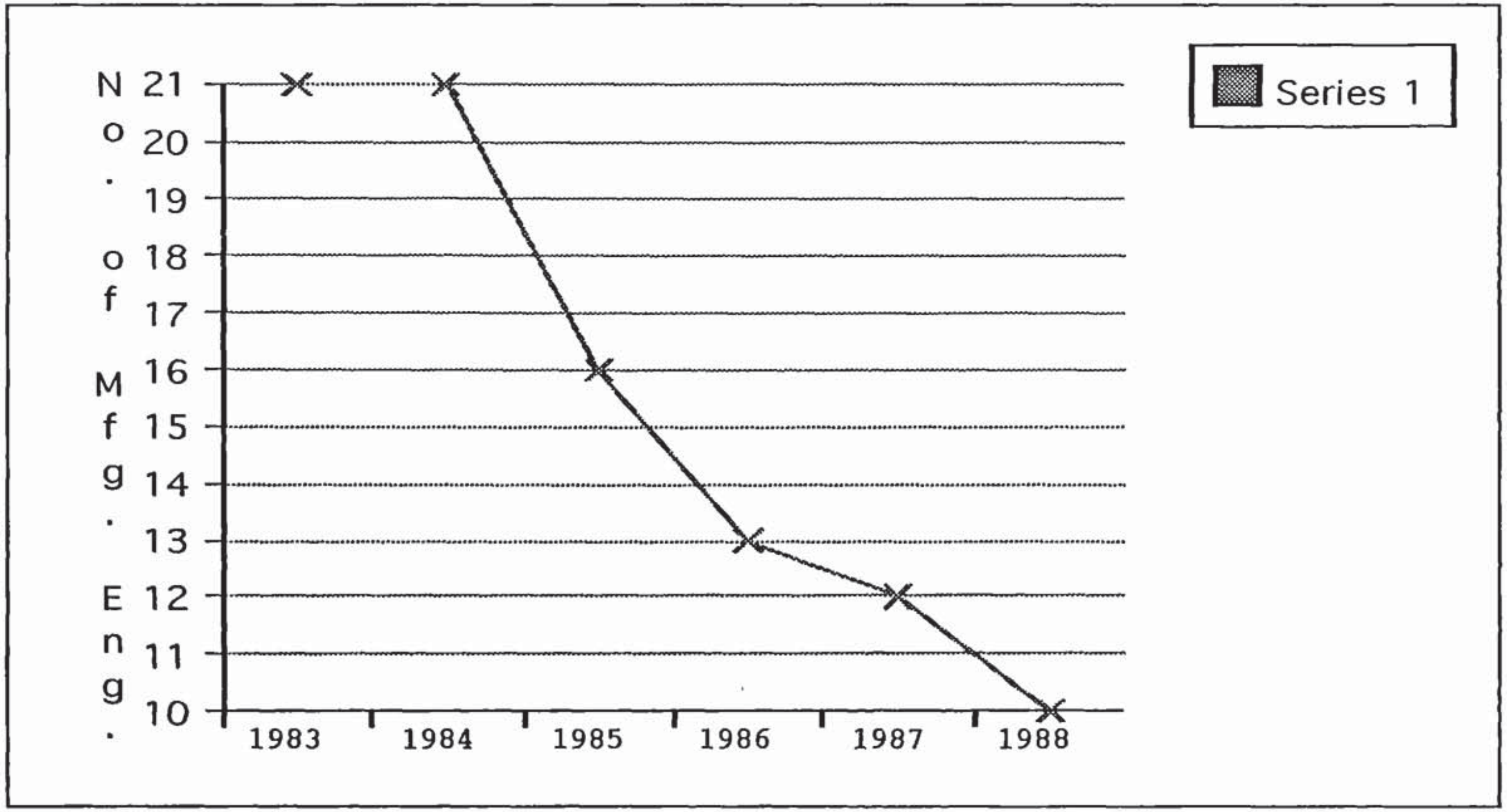
1. a reduction in setup time,
2. an increased productivity including labor and machine utilization (approximately 20%),
3. a reduction in inventory control activities, and
4. a reduction in rework and work-in-progress.

The production manager continued to say that management was willing to try new ideas that would improve customer relations, hence, quality improvement and time to market delivery. These preliminary results, among other intangible advantages, had been presented to senior management and a decision was made to implement group technology for the company's operations at this particular facility.

An implementation team was created to complete a feasibility of the best practice for their operations. The team included members from engineering, purchasing, finance, and a member from human resources department for assessing any training needs. The initial training included the key managers who were essentially responsible for the implementation process. However, other employees were trained over a longer period.

He left the previous company about five years after the introduction of group technology to join his current employer as the production manager. In addition to benefits mentioned earlier from the pilot study, he shared the data in Figure 6.4.

Figure 6.4
Number of Manufacturing Personnel Reduction



The production manager agreed that with the research data that group technology, implemented properly, could significantly and positively affect the operation. He pointed out that at times, some managers confuse advanced manufacturing technology with automation. They view its benefit as direct labor savings rather than strategic plans. He continued to explain, based on his experience, that labor unions regard technology as a threat to job security.

From the corporate financial point of view, he explained that "technology is not usually justified adequately, and that the company is then perhaps deprived of its' important and longer-term benefits[1]". He believed that the educational institutions at first, and the industry as a whole, should take responsibility for reinforcing the lack of system awareness. He pointed to the organizational structures by saying:

> "Individuals follow a particular path, at a rather young age, with progression along that career path that logic is not so much need-driven. Thus the engineer is normally trained in a specialized domain. Similarly, financial, marketing, sales or other non-technical personnel is unlikely to have an obligation to, or appreciation for, other functional areas[1]".

Group 3: Mechanical Industry, Company F

Company F, unlike all the other companies which were publicly held, is a privately held organization specializing in producing mechanical parts and sub-assemblies for the automotive industry. The interview was with the president and partner who previously was the manufacturing and production manager of a large international industrial corporation. The company presently employs ninety people,

1. Production Manager, Troy, Ohio; May 10, 1996 and Dec. 5, 1997

of which eighty are involved in manufacturing activities. They have 25,000 square feet of floor space devoted to manufacturing. Eighty percent of all activities are related to machining and fabrication, according to the president, with the remaining twenty percent devoted to sub and final assembly processes.

The company can be considered a job shop where a large variety of parts are produced with general function machines, according to the customer request. However, on an experimental basis he noted, they "have recently implemented cellular manufacturing for a product line with significant and positive results obtained in improvements in quality, interpersonal communication, and profits. The company is planning to continue with this concept throughout its facilities." He stated that a recognition of some similarities of the parts that the company was already producing for this customer in the auto industry and the quality specification of the ISO standards (International Organization for Standardization) which were now required of this customer resulted in the implementation of the cellular system. He added that upon this fact and his knowledge of group technology, he discussed the idea of an arrangement of group families with his production personnel. While the company continued the production activities in the traditional job shop layout, a feasibility team was formed to assess the introduction and the design of a manufacturing cell.

The team consisted of two manufacturing engineers, a production control supervisor, purchasing manager and the president himself acting as the chief financial officer. The responsibility of the team was, over a three-month period, to resolve if a manufacturing cell can be designed, and to identify its advantages over current machine layout.

The team met on a weekly basis to consider various issues from an addition and a new layout to plant facilities to financial requirements for completion of the building.

A determination was reached at the end of this period to not only implement the proposed addition and cellular layout, but also to acquire consulting services from the Advanced Integrated Manufacturing Center from a local community college in order to expedite the completion of the project. The grouping of parts was based on similar physical characteristics, machines, and processes. Based on the recommendation from the consultant, a detailed execution plan was worked out and the plan, from the time of realization of the idea, to the start of production in the new small addition took a little over a year. Since none of the employees had any significant hands-on experience in cell design, the consultant provided a full simulation of cell operation. The president acknowledged that in spite of the limited data available to make detailed comparisons, after two years of operation of the cell, he is certain that a number of improvements had been accomplished but hesitated to share any financial or numerical values. However, he concluded that a greater communication within the company and at all levels was perhaps the most important gain since the introduction of the cell. He also added that:

1. operational efficiencies had been improved perhaps by as much as 10-15%,
2. enhanced and concentrated pre-production activities to assure the validity of processes were improved by approximately 15%,
3. the focus on quality was better (reduction in scrap or rework), and
4. increased machine utilization and refined process planning occurred.

He also noted that the internal feasibility study was rather negligible compared to financing for the new addition to the building and purchase of two new fully automated larger machines (slightly less than one million dollars).

He supported the results of the mail survey in that group technology and cellular manufacturing have greatly affected all aspects of his organization.

However, in reference to technology justification, as a small organization, he pointed to a major concern with trends in 'investors' mandate for quick returns." He was also concerned with the degree of importance given to "short-term results required by the financial institutions to the point that would limit his ability to respond to new technology." He believed that, among many top executives, "a short-term orientation exists at the expense of longer-range issues." He also contributed the lack of integration or system recognition to the current educational system that reinforces such rigidity. He summarized, from his reading, by stating that:

> "To demolish the differences between engineers and sales, they must work together at reforming their relationship. They can and should build a stronger connection and that ample enhancement will then be feasible when each agrees to its responsibility whilst compromising their individual premonition (less market lucidity, and yes, less exemplary product)[1]".

In summary, based on these interviews, a number of issues were raised. These included such issues as:

1. do engineers with the superb education, skills and talents make the best managers? The overwhelming opinions were that there is a significant difference between being an excellent engineer and in being an effective manager;

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1. President/Partner, Troy, Ohio; May 10, 1996 and Jan. 9, 1998

2. an excellent engineer can be an effective manager if, in addition to technical training, a formal management and business training is provided. This missing connection for an engineer to be effective managers seemed to fall short of appropriate education and training; in areas of situational interpretation, business decision making and preference analysis, risk analysis, and an awareness of sales and marketing in school as part of the overall engineering education;
3. management in today's global market demands a new class of business and technological skills.

   These further included:

   A. an effective understanding and the proficiency to guide critical organizational goals along with the tactical skills to insure successful implementation;
   B. organizational and technical skills to carefully analyze customer prerequisites and anticipation;
   C. skills to choose, formulate, and participate in teams to ensure that they can accomplish accepted objectives[1]
   D. effective identification of resources for planning and introduction of technology and their application and new products; and
   E. effective interaction with all functional members of the organization to maximize growth.

6.4 Data Analysis of Cases

As was reviewed earlier, there are several popular methodologies used in conducting research. For the purposes of these cases, a combination of survey and personal interviews was chosen to collect the data for analysis.

Similarly, as discussed earlier, due to the limited number of cases in this research, Analysis of Variance for the cases was not possible. The researcher needed some type of a tool to compare the results of the case studies to those of questionnaire. Although the sample was very small, a 'T' test was the only available option to allow for such broad comparison. As such the results of the 'T' test should only be used in conjunction with the results yielded by the questionnaire and thus should not be considered separately. Therefore, this research employed a 'T' test that would yield in an equivalent *P>F* and could then be compared to the original analyses. In addition to the 'T' test, two correlation analyses were also completed. The Cronback Coefficient was performed to validate the list of questions used in these cases with alpha equal to 0.935. More specifically, the following comparison were made:

1. Perceptions of technical vs. non-technical administrators,
2. Perceptions of technical administrators among themselves, and
3. Perceptions of non-technical administrators among their own group.

Upon completion of the statistical analysis of the cases, Table 6.1, subsequent telephone interviews were conducted with at least one other member of these same organizations in order to further investigate and validate the results of the questionnaire used in this section.

In spite of some inconsistencies, such as work experience, the participants had very strong opinions on the issue of technological change. In particular, formal higher or university education, on-the-job training, and demands by the financial institutions for short-term return on investment, were important factors that limited adoption of new technology. This was supported, the participants felt, by a lack of understanding of needed training throughout their organization for successful implementation. This scenario is supported by Halberstan (1989), who states that reckless control of manufacturing companies' finances by a financial organization has been a critical ingredient in the loss of competitive position by American Corporations. Their promised purpose, improving shareholders' reward, disregards the interest of employees, suppliers, customers, and others who also deserve considerations.

Table 6.1
General Linear Model
Case Studies

Questionnaire Item	Sum of Squares	P > F
1. GT improves production-engineering activities.	8.167	0.0078
2. GT improves design-engineering activities.	6.000	0.0001
3. GT improves quality-engineering activities.	2.667	0.0161
4. GT improves purchasing & buying activities.	6.000	0.0257
5. GT improves production-planning and stock control activities.	10.667	0.0013
6. GT improves direct labor activities.	8.167	0.0022
7. GT improves marketing and sales activities.	10.667	0.0013
8. GT improves management activities.	13.500	0.0001
9. When AMT is justified on the basis of a strict financial analysis, its potential is never achieved, because:		
A: Managers confuse AMT with traditional automation. They perceive its primary benefits as direct labor savings rather than strategic capability enhancement.	24.000	0.0001
B. organized labor sees AMT as a threat to job security & resists its implementation.	0.667	0.1161

Note: This analysis was completed using The SAS System by SAS Institute Inc., Cary, NC. USA

Table 6.1
General Linear Model
Case Studies
(Continued)

Questionnaire Item	Sum of Squares	P > F
C. AMT is not justified on the basis of all factors, and the company is deprived of important assets.	13.500	0.0001
10. There is a great deal of agreement among American managers that a short-term orientation exists at the expense of longer-range issues.	13.500	0.0001
11. In justifying AMT, production-engineering personnel believe that AMT is the wave of the future, and include strategic as well as financial factors considered in appropriation decisions.	0.000	0.0001
12. In justifying AMT, financial personnel noting that AMT requires larger investment and has a higher operating cost, are mainly concerned with its financial considerations.	4.167	0.0075
13. The present educational system reinforces the lack of system awareness by teaching subjects manufacturing processes and production management in isolation from one another.	1.500	0.0001

Note: This analysis was completed using The SAS System by SAS Institute Inc., Cary, NC. USA

Table 6.1
General Linear Model
Case Studies
(Continued)

Questionnaire Item	Sum of Squares	P > F
14. The educational system, in statement 13, is repeated in career structures where the decision to follow a particular path is often taken at a rather young age and the progression is along that career path where logic is not so much need driven as traditional founded and historically reinforced. Thus the engineer is an engineer and is normally trained in a rather narrow specialized domain. In similar fashion, non-technical personnel are unlikely to have an ongoing commitment to any other functional areas.	1.500	0.0001
15. The personnel in majority of companies is composed of people whose education, training and experience is often discipline-based and thereby not well suited to taking an overall view of the business.	2.667	0.0161
16. Marketing inertia can lead to organizational rigidity in reacting to change.	6.000	0.0001

Note: This analysis was completed using The SAS System by SAS Institute Inc., Cary, NC. USA

Table 6.1
General Linear Model
Case Studies
(Continued)

Questionnaire Item	Sum of Squares	$P > F$
17. The competitive strategy is solely the domain of finance and marketing.	10.667	0.0013
18. Anticipated AMT decisions are related to a desire to increase profitability, but are constrained by start-up performance difficulties sometimes associated with AMT.	2.667	0.0161
19. It is important to the world of industry that technical and non-technical personnel should combine their efforts in an environment which assists with the simplification of the tasks of both parties.	8.167	0.0078

Note: This analysis was completed using The SAS System by SAS Institute Inc., Cary, NC. USA

These case studies can simply reflect the following summary by Ketchum and Trist (1992):

> "In one group of functional VPs of a large US corporation, who were meeting to consider how the organization might be made more adaptive to the future, one ventured the opinion that he saw no reason to spend time on the future: "Let's focus on profit.". And in this roomful of intelligent managers, the attitude towards the short run was so prevalent that no one chose to challenge him. No more time was spent on the future that day." (Ketchum and Trist, 1992, p. 57).

The present research findings (mail survey and case studies) in many respects, mirror those of research completed in Australia that concluded a substantial number of companies have embraced AMT and some have reported links between AMT decisions and business strategy (Weill, Samson and Sohal, 1991). However, it is not clear to Weill, Samson and Sohal, if upper management support will continue into implementation. They maintain that:

> "There are also limitations in AMT investment decision-making, particularly in large firms, caused by rigid evaluation systems which don't adequately consider non-cost advantages."

Reilly and Ozatalay (1996, p. 31) provide a summary that explains the need for change in "Yesterday's Organization in Today's World" as:

> "In summary, organizational management needs to be a partnership relationship between position power and expertise as it is distributed throughout the organization - but within and without managerial ranks."

It should be noted that the reason for these case studies was not only to validate the results obtained by empirical mail survey analysis, but also to solicit comments both from questionnaire respondents and others to allow the inclusion of perceptions of respondents which were not included in the mail survey questionnaire.

With the completion of the case studies, the following major points were identified:

1. Advanced manufacturing systems, and group technology specifically, was perceived as an alternative manufacturing system.
2. While there was some agreement on the benefits of advanced manufacturing systems and group technology, there was no conformity on the implementation when weighed against the cost of implementation.
3. The non-technical administrators were more interested in the short-term financial gains, while the technical administrators were more interested in the long-term benefits of advanced manufacturing systems.
4. There are differing perspectives of the benefits of implementing group technology between publicly and typically larger held corporations and smaller privately held organizations.
5. There is an acknowledgement between the technical and non-technical administrators that they need to work more closely to possess an overall understanding of the short-term and long-range goals of the organization and the manufacturing systems that will help achieve these goals.
6. There is a lack of balance in the higher education of individuals. Those in the technical and engineering fields do not have the business skills, and those in the business

and financial fields lack the technical knowledge to properly decide on the benefits of technology.

Based on the findings from these cases, which were similar to those of the mail survey, it is concluded that implementation of advanced manufacturing systems or group technology presents a new challenge to those in manufacturing in today's competitive marketplace. While many agree with the benefits, the cost of implementation is a major factor to organizations. The non-technical (financial) administrators were motivated more by the return on investment than the overall benefits gained in the long-term. The technical (engineering) strongly believed and supported the long-term benefits as a sound business judgment or decision.

The relevancy of potential benefits of advanced manufacturing systems and group technology differs greatly between the private and publicly held companies. There seemed to be an expected demand for a certain return on investment with larger companies, while the smaller companies were more apt to experimentation and implementation. However, there was an agreement for a better understanding of the overall organization's needs by all its members. Although these findings mirror those of the empirical analysis in perception, they perhaps indicate that not only does there exist a difference in perception, but more importantly, the external factors (lending companies, educational system, and previous experiences) all have major impact on the ability of an organization to implement new technologies.

The management and implementation, of group technology or other technological change requires cooperation between individual functions of the organization and their managers.

Especially in a manufacturing environment, there are many variables from market share to customer requirements and competitive priorities that need to be evaluated in addition to monetary considerations, if the organization is to excel in the fast changing technological and global market.

CHAPTER 7

DISCUSSION, CONCLUSION, & RECOMMENDATIONS

7.1 Introduction

This research was designed to examine the consistency of technical and non-technical administrators' perceptions towards management of technological change and group technology in the food equipment and preparation manufacturing organizations in the United States. This research first provided the necessary literature review (Chapter 1, 2, 3, and 4), then the findings of the mail survey empirical analysis (Chapter 5) and the case studies (Chapter 6) were presented. Presented in this chapter are: (1) discussion, (2) conclusion, and (3) recommendations.

7.2 Discussion

The mail survey questionnaire, in this research, was mainly divided into functional areas such that adequate coverage was given to individual departments in the organization. In Chapter 5, a summary of the results of the ANOVA analysis was presented. It stated that there exists a statistically significant difference between the technical and non-technical administrators' perceptions towards group technology.

It was found that the technical and non-technical administrators did not perceive the benefits of group technology and technological change to the same degree. The areas which were viewed as more important by technical administrators were: (1) production engineering, (2) design engineering, (3) quality engineering, (4) production planning and inventory control, and (5) direct labor. On the other hand, non-technical administrators did not view these same areas as important. This difference in perceptions, between the two groups, was also supported by the case studies. To recall this, the vice president and general manager of company A, did not agree with the literature and the results of the mail survey in that the company will continue to justify the adoption or implementation of new technology on the basis of financial justification. Whereas, the senior manufacturing engineer at the same company felt that the non-technical managers were mostly concerned with the 'bottom line' (hence: return on investment).

Second, non-technical administrators' perceptions of benefits of group technology and technological change were lower than their perceptions to those same areas. These were: (1) purchasing, (2) finance, (3) marketing and sales, and (4) management functions.

It was established that technical and non-technical administrators' associated different levels of importance to the benefits of group technology and technological change. Some areas were perceived as more important by technical administrators, whereas, some other areas were rated as more important by their non-technical colleagues. Technical administrators viewed more importantly (1) benefits associated with group technology, and (2) adoption and implementation of new technology. These finding were somewhat consistent with the research literature. Some findings reinforced prior research results, and other findings were not evident in previous studies (Fazakerley, 1974 & 1976; Burbidge, 1975; Hyer and Wemmerlov, 1984; Huber and Hyer, 1985; and Gallagher and Knight, 1986).

However, one finding in the present research as to how the technical and non-technical administrators perceived the benefits of group technology and technological change was not compatible with the literature. This finding could not be related to the literature because no mention was made in prior studies. It is noteworthy that Burbidge (1975), Hyer and Wemmerlov (1984), and Gallagher and Knight (1986) had considered some of the benefits achieved from group technology as basic to most manufacturing organizations.

The findings of the first hypothesis included areas which did not prove consistent among the technical and non-technical perceptions of the benefits of group technology. Technical administrators tended to rate those areas associated with engineering and production as more important, which were generally consistent with the literature. Non-technical administrators, on the other hand, did not view these benefits the same and rated them as less important, which was partially consistent with the literature.

Findings relative to the second hypothesis revealed that non-technical administrators did not have a budget commitment to technological change and benefits associated with group technology. Consequently, a trend among these administrators could be established. The results of testing the third hypothesis showed that, generally, technical administrators viewed technological change and the benefits associated with group technology to be important. As a result, a trend among these administrators could also be identified. Some of these findings were consistent and other findings different from the trends reported in research literature. Analysis of the case studies (i.e. company C) also support this finding, where the production manager felt that the educational system must reinforce specific subjects and that they should remain separated from other topics. He believed that this will provide for a better evaluation based on one's field of expertise.

Furthermore, some companies used the no-budget system discussed in Chapter 2, in allocating funds for technology.

Since this type of budgeting process is highly subjective and is based on appeals rather than a structured plan, it could also result in inadequate budgets.

The participants in the case studies support most of the above findings that:

1. proper utilization of advanced manufacturing technologies, such as group technology, can and will yield to a better utilization of man and machine;
2. any elimination or at least significant reduction in new parts design would directly have a positive effect on the production planning efforts;
3. one participant indicated, from first hand experience, that classification and coding through the introduction of group technology significantly reduced the design cycle time in the design department;
4. the majority of the participants agreed that using the same part or parts of similar design, once it has been proven and the details of manufacturing have been worked out, will improve production yields by eliminating the need for most of the previously reworked or scraped parts. The same was agreed that expediting efforts will be significantly reduced if there were no need for reworking of the parts already produced;
5. many of the participants indicated that it is always desirable to reduce the delivery lead time; however, the business manager of one of the electronics industries was not convinced that group technology will actually accomplish significant reduction in work in progress.

Although the area of reduced raw material stock had come up a number of times, the specific area of purchasing and buying function did not compare as much as other areas.

The area of education, the deficiency between practice and education, was identified by a number of companies in the cases. The literature has revealed that many survey's among these industrial groups indicated a general satisfaction with the scientific and technical literacy, but expressed concerns in the shortcomings of managerial skills among engineering graduates. Mason (1998), in his study of a new manufacturing engineering curriculum, has found that the ability to understand manufacturing processes, the creation of competitive advantage through planning and strategy, and to economically justify their decisions, was of top priority identified by the survey of manufacturing companies in the Pacific Northwest. In addition, according to Chelst, Falkenburg, and Nagle (1998) decision making and management of risk, the management of technology and technology change, and business management skills were identified as important components of the curriculum.

7.3 Conclusion

This research was developed with the question of whether there is any significant difference in perceptions between the technical and non-technical administrators responsible for manufacturing activities. Based on literature discussed earlier, this study was designed based on the premise that a strong level of agreement between the functional areas of technical and non-technical administrators would lead to the enhanced performance of the organization; whereas disagreement would lead to poor performance. The research has shown some shortcomings among these groups. It was found that technical and non-technical administrators, in the food equipment industry, perceived some of the benefits of group technology differently. Such findings suggest important conclusions about the utilization of technology and change, and about new areas of study which should be undertaken to enhance the role of technology in manufacturing, in general.

In spite of the absence of some, perhaps important issues, the research has identified a level of interpretation on an educational definition as the need for change and benefits of advanced manufacturing technologies. The review of literature (Plossl, 1991; Sohal, Samson and Weill, 1991; and Steudel and Desruelle, 1992) has also delineated that a shortage of knowledgeable and skilled managers introduces the key strategic factor yielding to operational deficiencies in manufacturing industries including the Food Equipment industry . These findings focus on the urgent importance of development in explaining the differences in perceptions between these groups, who are responsible for manufacturing activities and strategies.

The strategic conflict that affects an organization's ability is a shortage of educated and qualified managers who can fill both technically and financially rewarding and skill demanding positions in industry. This research has confirmed previous findings that attempted to assess technology.

Management in manufacturing firms must be willing to maintain a well trained work force. As the findings propose, a key characteristic is the existence of an experienced work force, both financially and technically. The important suggestions developing from these findings are:

1. the prerequisite to improve the educational level of those responsible for manufacturing activities,
2. the critical need among manufacturing firms to obtain skills which they lack toward the important role played by educational institutions,

3. develop the degree of relationship between industry and academic missions, past theory & principles, and
4. support the scope of educational institutions to include internships and other channels for inspiring the distribution of applied knowledge and skills.

The research indicated that technical and non-technical administrative members perceived technological change differently. Whereas, the non-technical administrators considered the short term budgetary responsibility more important than potential long term benefits, the technical administrative members were less concerned with the budgetary factors. Therefore, one conclusion might be that budgetary responsibilities are more important perhaps by the top senior management and the share holders.

This issue was studied by Putterill, Maguire and Sohal (1996) and they concluded that the financial analysis of new projects is the responsibility of the relevant task force(s) - or it simply should not be relegated to an accounting function. This is to say that based on theory, survey, and practice, these require changes to the traditional role of financial analysis, in which it extends the investment process to one that combines both strategic and financial management considerations.

The basic methodological limitations must also lead us to view the conclusion with a degree of caution. The major drawback of the study is the industry, in one country, and the fact that it is only a small sample of the larger industrial world. These details imply that we must be very cautious in making any generalizations of these findings to a larger population. The second potential drawback relates to questions about the degree of uniformity in gathering and recording the data. To accommodate these two limitations, the study embraced a qualitative approach and utilized a combination of intuitive and quantitative analysis techniques. Though the study did not claim to make statistically significant generalization to a larger population, it did utilize the rich source of data to arrive at findings that are suggestive of trends among a larger population.

7.4 Recommendations

This research utilized perceptions as a comparative evaluation tool. Although findings were consistent with the results of previous research, direct evaluation of technological change and its needs could provide the consistency or the variation between perception and more direct evaluation techniques. For example, the actual budget and measurement of importance of technology would show the degree of consistency between perception and direct techniques. Such findings would, in turn, help clarify the nature of the relationship between perceptions, actual importance, and budget commitment to technological change. The questionnaire was organized to gain insight into perceptions without seeking open remarks from respondents to avoid possible difficulties in analyzing comments. This research elicited comments from the questionnaire respondents to allow the inclusion of possible perceptions of respondents which were not included in the mail survey.

Finally, this research found that there was some degree of variation when the responses were compared for each organization. Therefore, future studies focused within organizations to investigate possible causes of these variations would be helpful.

The results of this research offers opportunities for further studies in several areas. This might focus on the following issues:

1. What is the relationship between a firm's perception of technological change and its intended turn-around strategy?
2. How accurately does management's perception of their firms' strategic policy reflect reality?
3. What is the relationship between the need for technological change, its implementation and its benefits?
   - A. Short term return on investment was viewed as more important by the financial administrators as compared to potential long term benefits that may have been gained by new technology. Future studies could determine the specific significance of technological changes to financial administrators.
   - B. The technical administrators viewed technological change as more important for long term benefits that may have been achieved by new technology. Since no previous studies had identified this finding, future studies could determine the specific significance of technological changes and its associated financial resources availability (cost/benefits analysis) to technical administrators.
   - C. The need to determine the significance of technological change to non-technical administrators.
   - D. The need to specifically inquire about technological change as it's related to the entire organization. A study that

would determine the specific relationship between importance and the need for technology and change.

4. The need to determine if the findings of this research would be consistent with studies involving larger populations and inter-organizational comparison.
5. The need for using direct evaluation of technological change, rather than perception, to determine the consistency of the variation between perception and more direct evaluation. In addition, allowing more respondents to make comments may add insight into the findings of similar studies.
6. The need to determine the causes of technical and non-technical administrators' response variations at individual organization levels may also help add additional insight.

This is summarized, in short, by Plossl (1991, pp. 19 and 24):

> "The most important factor is education of executives and managers to develop their full understanding of how manufacturing really works and how it should be managed......However, their lack of understanding of manufacturing, coupled with use of wrong performance measures causes their activities to be very destructive of sound performance."

Administrators at the University of St. Thomas state that the newly developed 'Technology Management' program will produce strategic industrial-technical leaders who can guide their organizations' technical strategy.

According to Moore, president of Indiana State University (NAIT, Spring 1998), the newly approved technology management program at Indiana State University will enhance the state's leadership position in technology-based education and research, will prepare students to teach technology, conduct research and provide leadership in industry.

> "Indiana Commission for Higher Education on Friday (Feb. 13) approved a doctoral program in technology management that is the first of its kind in the nation and will be administered by Indiana State University's School of Technology."
> (NAIT, Spring 1998, p. 52)

The development of such programs across the U.S.A. and the globe is, perhaps due to increased demand for qualified individuals with knowledge of critical scientific, technical and business areas who can usher their organizations into the future. This was the basis for this research hypothesis; that there is a significant difference in perception of technical and non-technical administrators' perceptions toward advanced manufacturing systems and management of technological change. While the outcome and effectiveness of such programs remain to be validated, it is the graduates of these programs that will have a major impact on the future technology utilization and implementation.

In order to amplify the knowledge of management of technological change in the field of manufacturing; educators, policy-makers and business and industries need to have intuition into likely causes, such as perception, that was the purpose of this research and had not previously been investigated. While these conclusions could be used as broad recommendations for curriculum development and industry evaluation, specific and pertinent topics which resonate, not only current manufacturing practice, trends, but also future need for change, could be addressed.

This chapter has provided a more in depth explanation of the findings of the research, the mail survey as well as case studies, and incorporated a discussion on these findings. It has also provided some recommendations for future research in the area of management and implementation of technological change.

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Appendix A
Food Equipment Manufacturer Industry Data

Manufacturere	Product Category/ies	Start Date	Type	Est. Worth	Est. Sales Volume
A-F Industries, Inc.	Commercial washing machines & industrial process drying ovens	1971	Private	2.1	6.4
Alto Shamm, Inc.	Full line cooking Equipment	1955	Private	8.1	30.8
Alvey Washing Equipment	Warewashing equipment	-	Private	-	-
Amana Refrigeration, Inc.	Microwvae ovens	1965	Private	268.7	940.0
American Delphi	Commercial waste disposers & stainless steel sinks	1976	Private	-	-
Anetsberger Brothers, Inc.	Bakery and food serving equipment	1982	Private	1.0	5.6
Baker's Aid	Full line bakery euqipment	-	Private	-	-
Bakers Pride	Ovens and Broilers	1946	Private	-	10.0
Baxter Manufacturing Co.	Racks, Revolving, & proof boxes	1956	Private	3.8	22.1

Appendix A
Food Equipment Manufacturer Industry Data
(Continued)

Manufacturere	Product Category/ies	Start Date	Type	Est. Worth	Est. Sales Volume
Belshaw Brothers	Full line bakery euipment	-	Private	-	-
Benier USA, Inc.	Food preparation & cooking equipment	-	Private	-	-
Berkel, Inc.	Slicers & food serving machinery and repairs scales and food serving equipment	1916	Private	3.5	27.8
Beverage-Air	Refrigeration equipment, pizza/sandwich tables, and display cases	-	Private	-	-
Biro Manufacturing Co.	Meat & food processing machinery	-	Private	-	-
Bizerba USA	Full line scales, wrapping, slicers, and vacum packaging	1984	Public	-	-
BK Industries	Barbecue king rotisseries pressure/open fryers	-	Private	-	-

Appendix A
Food Equipment Manufacturer Industry Data
(Continued)

Manufacturere	Product Category/ies	Start Date	Type	Est. Worth	Est. Sales Volume
Blakeslee	Food service equipment including dishwashers, mixers, and peelers	1983	Private	-	11.0
Blodgett - Combi	Full line bakery equipment	1988	Private	-	-
Bolgett - Oven	Fuul line bakery equipment	1988	Private	-	-
Butcher Boy	Full line meat room equipment	-	Private	-	-
Champion Industries, Inc.	Commercial dishwashing machines	1980	Private	-	-
Chesterfield	Chicken frying equipment	1967	Private	1.5	15.7
Cleveland Range	Cooking equipment	1930	Private	-	55.0
Crispy Lite Company	Total chicken programs	-	Private	-	-
CTX/Gemini	Ovens	-	Private	-	-

Appendix A
Food Equipment Manufacturer Industry Data
(Continued)

Manufacturere	Product Category/ies	Start Date	Type	Est. Worth	Est. Sales Volume
Dean Industries	Food processing equipment	-	Private	-	-
Delfield	Refrigeration equipment	1948	Private	2.5	116.0
Detecto Scale Co.	Scales	-	Private	-	-
Digi	Weighing/wrapping equipment	1974	Private	-	-
Dito Dean Food Prep.	Food preparation equipment	-	Private	-	-
Douglas Machines Corp.	Commercial cleaning equipment	1989	Private	0.4	4.8
Empire Baking Equipment	Wholesale bakery equipment & store front equipment	1977	Private	-	19.0
Exact equipment Corp.	Full line weighing & wrapping equipment	1986	Private	-	-

Appendix A
Food Equipment Manufacturer Industry Data
(Continued)

Manufacturere	Product Category/ies	Start Date	Type	Est. Worth	Est. Sales Volume
Federal Industries	Refrigeration & non-refrigertaed display cases	-	Private	-	-
Flavor Crisp of America	Pressure fryers, smoker ovens, & sandwich grill	1988	Private	-	-
Franklin Products, Inc.	Gas & electric cooking and holding equipment	1992	Private	-	-
Frymaster	Commercial food service equipment specializing in deep fat fryers	1988	Private	-	81.0
Garb-El Products Co.	Disposers	-	Private	-	-
Garland	Full line cooking equipment	1973	Private	-	40.0
Giles Food Equipment	Fryers & hoods	-	Private	-	-
Globe Food Equipment Co.	Slicing machines	1991	Private	-	-
Groen	Combo-steamer ovens, convection steamers, ciik chill systems	-	Public	-	-

Appendix A
Food Equipment Manufacturer Industry Data
(Continued)

Manufacturere	Product Category/ies	Start Date	Type	Est. Worth	Est. Sales Volume
Hardt Equipment Mfg., Inc.	Deli production equipment	1983	Private	-	-
Hatco	Specialty resturant equipment, booster heaters, toasters, Etc.	1950	Private	-	35.0
Heat Sealing Equipment Mfg., Co.	Stretch/shrink wrapping skin/blister packaging vacum chambers, Etc.	1958	Private	-	8.0
Henny Penny	Commercial cooking & food warming equipment	1976	Private	-	52.5
Hickory/Old Hickory	Rotisseries, combi ovens	-	Private	-	-
Hollymatic Corporation	Patty machines, meat saws, grinders, vacum machines, Etc.	-	Private	-	-
Hussmann	Full line refrigerated systems	1978	Private	348.0	859.5

Appendix A
Food Equipment Manufacturer Industry Data
(Continued)

Manufacturere	Product Category/ies	Start Date	Type	Est. Worth	Est. Sales Volume
In-Sink-Erator	Disposers	-	Public	-	-
Ishida Corporation of America	Weighing/wrapping equipment	-	Private	-	-
Lincoln Food Service Products	Full line cooking equipment	1957	Private	-	57.6
Litton	Microwaves	-	Private	-	-
Lucks Food Equipment Co.	Full line bakery equipment	-	Private	-	-
LVO Manufacturing	Warewashing equipment	1980	Private	0.4	3.0
Mannhart, Inc.	Food processing equipment	1985	Private	-	-
Matsuhita, Inc.	Wholesale electronics parts and equipment	-	-	-	-
Merco	Heating equipment	1956	Private	-	-
Mettler Toledo Scales and Systems	Full line weighing and wrapping equipment	1901	Private	48.8	371.7

Appendix A
Food Equipment Manufacturer Industry Data
(Continued)

Manufacturere	Product Category/ies	Start Date	Type	Est. Worth	Est. Sales Volume
Middleby Corp.	Full line cooking equipment	1978	Public	1.4	130.0
Middleby Marshall/CTX	Full line cooking equipment	-	Public	-	-
Mies Products, Inc.	Food service equipment and supplies	1952	Private	-	2.5
MJR Industries, Inc.	Food service equipment	1974	-	2.3	11.0
Moline Machinery Ltd.	Mixing/bakery euqipment	1945	Private	3.2	8.5
Multivac, Inc.	Vacum packaging equipment	1987	Private	-	52.5
New Brunswick International	Commercial refrigeration equipment, Etc.	1974	-	-	-
Nu-Vu Food Service Systems	Bakery equipments and ovens	1974	Private	2.3	11.0
Oliver Products Co., Inc.	Full line bakery equipment	1981	Private	-	21.0

Appendix A
Food Equipment Manufacturer Industry Data
(Continued)

Manufacturere	Product Category/ies	Start Date	Type	Est. Worth	Est. Sales Volume
Panasonic Foodservice	Microwaves	-	Public	-	-
Patty-O-Matic	Food preparation equipment	-	Private	-	-
Pitco Frialator Co.	Fryers	1918	Private	-	-
Randell	refrigeration, tables, preparation and dough rollers	1975	Private	6.1	-
Revent, Inc.	Rotating rack ovens, proof boxes for baking industry	1979	Private	-	-
Robot Coupe USA, Inc.	Food preparation equipment	1967	Private	2.0	10.6
Rondo, Inc.	Bakery equipment-mixers, dividers, proofers, Etc.	1964	Private	-	8.0
Savory	Full line cooking equipment	1989	Private	-	-
Sharp	Microwaves	-	Private	-	-

Appendix A
Food Equipment Manufacturer Industry Data
(Continued)

Manufacturere	Product Category/ies	Start Date	Type	Est. Worth	Est. Sales Volume
Standex International, Corp.	Commercial refrigeration equipments, Etc.	1955	-	102.7	529.4
TEC America, Inc.	Scale systems, wholesale distributer of cash registers, POS & scales	1969	Private	-	65.0
Traulsen & Co.	Refrigeration systems	1939	Private	-	22.5
Treif USA, Inc.	Meat slicers & cutting machines	1992	Private	-	-
Tru Hone	Knife sharpening systems	1968	Private	0.2	1.3
True Food Service Equipment	refrigeration equipment	1958	Private	-	-
Univex	Mixers, slicers, meat grinders, Etc.	1975	Private	2.8	10.2
US Range	Full line cooking equipment	-	Private	-	-
Varimixer	Mixers	-	Private	-	-
Victory Refrigeration	Refrigeration	-	Private	-	-

Appendix A
Food Equipment Manufacturer Industry Data
(Continued)

Manufacturere	Product Category/ies	Start Date	Type	Est. Worth	Est. Sales Volume
Welbilt Corpration	Full line manufacturere	1907	Private	-	411.0
Weldotron Corporation	Wrappers & scales	1956	Private	6.8	30.4
White Consolidated Industries	Commercial food prep. equipment	-	-	-	-
WonderRoast, Inc.	Rotisseries	1962	Private	-	-

Appendix B

Classification & Coding,

Production Flow Analysis, and

Just-in-Time

The reader is reminded that, in the content of this research, the management of technological change, group technology is used as an advanced manufacturing philosophy. Classification and coding are major parts of group technology, and for this reason this section is provided.

> Component classification and coding was until recently the only known method of finding families. It was therefore an essential part of group technology. With the introduction of production flow analysis, it is no longer needed for this purpose. .....It says, however, that classification and coding is an important technique in it's own right; that it can make significant contribution to the later development of a group technology system, and that it should therefore be considered as a technique, or tool of particular importance to group technology. (Burbidge, 1975, p. 219)

In order to better understand this important area, both classification and coding and production flow analysis will be discussed in this section.

Classification is a division of items into classes according to their differences; that is an analytical view. It can also be defined as combining the individual items into classes according to their similarities, which is a synthetic view. Coding, on the other hand, is defined as the assignment of symbols to classes, where symbols convey information about the particular class. Standardization of material, purchased parts, fabricated components, subassemblies, and completed items to a particular group can be accomplished through informal or formal classification methods.

Numerical, alphabetical and alpha numerical are the most common types of codes. Codes are typically classified into three types: monocodes, polycodes and mixed codes as shown in Figure 1 (Gallagher and Knight, 1986). These systems can also be classified into specific and universal codes.

Appendix B, Figure 1

Structure of Classification Systems

Aston University

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From Group Technology Production Methods in Manufacturing (p. 130) by C. C. Gallagher and W. A. Knight, 1986, England: Ellis Horwood Ltd. Copyright 1986 by Ellis Horwood Ltd.

The monocode, or hierarchical codes (Figure 2), are constructed in such a way that each symbol amplifies the information provided in the previous digit or letter. The digits in monocodes can not be delineated alone, since they are dependent for their arrangement on the information contained in the previous symbols, such as the Dewey decimal system typically used in the libraries. This interrelationship of symbols makes coding designs somewhat difficult to construct. However, the advantage of hierarchical coding structure is that they allow the capturing of a great deal of information and are used for permanent data.

Appendix B, Figure 2

Hierarchical Coding System Structure

Aston University

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The polycodes, or feature codes, are independent of one another. Each feature code occupies a specific code field, and the value assigned to that position for any item is described in the same way irrespective of the preceding code assigned to that part. Polycodes are typically used for non-permanent data such as cost and are easier to construct than monocodes. The numerical polycodes have only ten digits and have a very limited capacity. Another drawback to polycodes is that they typically get to be very long.

Mixed-mode codes present a mixture of monocodes and polycodes. The coding scheme that creates mixed-mode codes is simple to construct and consists of many small codes linked such as polycodes. The mixed-mode code has distinctive advantages by securing the positive aspects of monocodes and polycodes, and are used to increase data storage capacity.

Specific codes are those that are specially developed to meet the needs of organizations and/or specific problems. In contrast, universal codes are those of general purpose in the same way as the Dewey decimal code system that can be used in any library. "The most common problem companies face in the area of coding and classification stems from the inability of codes to describe the material adequately." (Hyer & Wemmerlov, 1984).

In a design function, similarity could mean closely related geometric shapes or function, materials, size and dimensions. Similarities between parts, from a manufacturing point of view, could mean that they are processed in the same way. However, they can be quite dissimilar in geometric shape and design. Surveys have shown that in many organizations only 20% of the parts thought to need new designs actually require them; of the remaining new parts 40% could be built from an existing design and the other 40% could be generated by altering an existing design (Gunn, 1982).

A great number of coding systems have been developed over the years (as shown in Table 1). However, the four systems frequently used by U.S. Manufacturers are the BRISCH BIRN, OPITZ, CODE, and MICLASS/MULTICLASS (Hyer & Wemmerlov, 1985).

BRISCH Code System

One of the earliest systems, the BRISCH code, which is a general purpose code of 4-6 digits, was designed and developed by Brisch-Birn, Inc. in the United Kingdom and the United States. This system is all numeric, consisting of a primary and a secondary code. The primary code, a monocode structure, consists of four to six digits and deals with basic design and shape features. The secondary part, a

Appendix B, Table 1
Selected examples of worldwide Classification & Coding Systems

Systems	Organization/Country	# of Digits	Application
MICLASS	TNO (Holland & USA)	12	General
BRISCH	Brisch-Brin, Inc. (UK & USA)	4-6	General
CODE	Mfg. Data System, Inc. (USA)	8	General
OPITZ	Aachen Tech. Univ. (W. Germany)	9	General
BUCCS	Boeing Co. (USA)		
Ivanov	(Russia)	0 *	General
SAGT	Purdue Univ. (USA)		
STUTTGART	Univ. of Stuttgrat (W. Germany)	6	Flow turining
PERA	Prod. Eng. Res. Assn. (UK)		
PITTLER	Pittler Mach. Tool Co. (W. Germany)	9	General

Appendix B, Table 1
Selected examples of worldwide Classification & Coding Systems
(Continued)

Systems	Organization/Country	# of Digits	Application
ASSEMBLY PART CODE	Univ. of Massachusetts (USA)		
GILDEMEISTER	Gildemeister Co. (W. Germany)	10	General
DTH/DCLASS	Brigham Young Univ. (USA)		
ZAFO	(W. Germany)	21+	General
HOLE CODE	Purdue Univ. (USA)		
SPIES	(W. Germany)	4	Hot forging
LITMO	Leningrad Inst. for Pre/Optics (USSR)		
PUSCHMAN	(W. Germany)	3	
Sheet Metal			

Appendix B, Table 1
Selected examples of worldwide Classification & Coding Systems
(Continued)

Systems	Organization/Country	# of Digits	Application
CASTING SYSTEMS	(Japan)		
WALTER	(E. Germany)	3-5	Open die
forging			
AUERSWALD	(E. Germany)	4	
Cold Forging			
MITROFANOV	(USSR)	0 *	
General			
VPTI	(USSR)	Variable	General
VUOSO	Prague M/T Res. Inst. (Czech.)	4	General
VUSTE	Res. Inst. Eng. Tech. & Econ. (Czech.)	4	General

Appendix B, Table 1
Selected examples of worldwide Classification & Coding Systems
(Continued)

Systems	Organization/Country	# of Digits	Application
IAMA	IAMA, Ltd. (Yugoslavia)	8	General
SALFORD	(UK)	6	
PGM	PGM, Ltd. (Sweden)	10	General
KC-1	(Japan)	5	General
TOYODA	Toyoda, Ltd. (Japan)	10	
General			

(*) Classification without coding

From Group Technology - Applications to Production Management (p. 12) by I. Ham, K. Hitomi and T. Yoshida, 1985, Kluwer-Nijhoff Publishing. Copyright 1985 by Kluwer-Nijhoff Publishing; and From Group Technology Production Methods in Manufacturer (p. 133) by C. C. Gallagher and W. A. Knight, 1986, England: Ellis Horwood Ltd. Copyright 1986 by Ellis Horwood Ltd.

The secondary part, a polycode, is variable in length . It focuses on manufacturing-related information and is well suited to design retrieval and a variety of reduction applications. It has successfully been introduced in many firms of varying sizes. However, since the BRISCH system is a hierarchical code, the choice of particular characters from the various groups may be difficult (Gallagher & Knight 1986 and Ingram, 1982).

OPTIZ Code System

The OPITZ system, a commonly used coding system, was originally developed for investigation of component statistics by professor Opitz at the Technical University of Aachen, in the former West Germany. The complete code consists of nine code fields divided into two parts. The first five digits, or the primary code, focuses on part geometry, dimensions and features relevance for part design. The secondary code, a polycode, contains four digits and includes information applicable to manufacturing data such as raw material and tolerances.

> The form code has 5 digits. In the first digit the general shape of the workpieces are characterized, i.e. the part class, the workpiece being subdivided into rotational and non-rotational parts. For example, first digit numbers 0 to 2 are rotational parts of a certain L/D (length to diameter) ratio. The second digit and third digit are significant to the first digit numbers, i.e. the second digit defines the external shape and its relevant form element, the third digit describes the form and position of the main shape. The fourteen digit describes the plane machining and the fifth digit the auxiliary holes, the gears and the forming. (Opitz & Wiendahl, 1971, p. 184).

This system can be applied to machined parts, non-machined parts such as formed or casting, and purchased parts. This coding system was designed for general and universal applications and can suit specific applications with minor modifications and without difficulty. However, although some space is left in the code for manufacturer-specific types of components, some detailed data about classes of parts already handled by the coding system may not be accommodated without some alternation (Hyer & Wemmerlov, 1985).

CODE System

The CODE was originally designed in the late 1960s and is now marketed by Manufacturing Data Systems, Inc. This system, developed for design retrieval purposes, consists of an eight digit mixed-mode and alphanumeric symbols (1-9 plus A-F) codes. The first digit divides components into main classes and the other seven digits have specific significance. Both the physical and the functional characteristics are described by this system. However, some manufacturing data such as material and processes can not be included in this coding system (Eckert, R., 1975 and Schaffer, G. 1981).

MICLASS Code System

The MICLASS code, another popular coding system, was originally designed by The Netherlands Organization for Industrial Research and is marketed in the U.S. by a consulting firm based in Waltham, Massachusetts. This system is a mixed mode coding system that can be altered to fit the needs of individual firms. It can be used manually and is also available as a computer package. MICLASS uses twelve digits, most of which have fixed significance, to classify the engineering and manufacturing characteristics of each workpiece. The first four digits describe the main shape, shape elements and the position of the shape elements. The next four digits of the classification number code the main dimensions, the ratio of the dimensions and an auxiliary dimension. The next two digits, the ninth and tenth, classify the part tolerances including dimensional tolerances, surface roughness and form tolerance. The last two digits of the classification number deal with machinability and material (Houtzeel and Schilperoot, 1975 and Schaffer, G., 1981).

With the description of classification and coding systems given here, it is important to note that although there are differences in each system, they all serve one purpose. That is the heart of group technology that brings together similar components for design and manufacturing. Therefore any selection, of classification and coding systems, must include:

1. A system must be all-embracing. Do not classify only part of the group. It may be desired to bring more and more into the system at a later time.
2. A system must allow for future expansion. This is a requirement in today's ever-changing environment.
3. There should, for the sake of simplicity and elimination of any confusion, be only one place for an item to fit into the system.
4. Simplicity, documentation control, and accessible guidelines are necessary for effective and efficient operations.

5. The system must provide for permanent or logical characteristics. Although important, the variable data is best carried as supplementary data that are not part of an item itself.
6. Lastly, the specific needs of involved parties in the organization must be part of the system requirements.

Production Flow Analysis

Production flow analysis is a method used to simplify material flow systems and to find the family and group layout. The method is employed in four sequential stages. These include (Burbidge, 1975):

1. The Factory Flow Analysis (FFA), targets to find an efficient material flow system between different production processes in a factory. Major groups are found by combining processing units. These units are simply made from the list of machines that are used to carry out each process. The major groups found by this method include the greatest potential groups of compatible machines that can complete all the parts in their families without intermediary call to other major groups.
2. The Group Analysis (GA) is the second stage. The major effort is to break up the components and plant allocation into families of components and groups in a way that each family is completely processed in one group only. The basic goal of group analysis is to find the most

efficient division of the major groups into groups of a required size.

3. The Line Analysis (LA) or the third stage examines the flow of material between machines inside groups. It employs network analysis to resolve the route between the machines in a group, in order to discover the best arrangement for plant layout.

4. The final and fourth stage is called the Tooling Analysis (TA). Tooling analysis attempts to find tooling families of parts that use the same tooling in their set-ups. It also finds the optimum order of loading. Like line analysis, it uses a matrix to find the families of parts processed on each machine into tooling families and its arrangement of loading.

So far, the research has provided an introduction to the thesis, a review of literature in regards to management of technological change and various manufacturing systems. The next section will provide an overview of some of the benefits and the limitations of group technology.

JUST-IN-TIME MANUFACTURING Philosophy

Just-in-time, although not a manufacturing system, is known as zero inventories by some and is used in repetitive manufacturing by some of the more successful manufacturing organizations. The major objective of just-in-time is to have the right item at the right place and at the right time. In other words, to purchase and produce items only a short time before they are needed so that work-in-process inventory can be kept low. This practice not only reduces working capital requirements, but also reduces the need for space and shortens the thorough time, since materials spend very little time in queues.

Many companies, including American ones, according to Duncan (1988) have made just-in-time an integrated part of their business. However, in many cases companies did not respond to just-in-time as a necessary step in their development before deciding on its suitability. Just-in-time has been embraced as the last hope for survival in the global and competitive environment. As a result, the level of commitment to the concept has been high. Characteristics of just-in-time are usually found to include the following (Duncan, 1988):

1. Correct definition: Just-in-time must be understood as a philosophy. It can be implemented in a project, but it must be understood as a never ending change in the way business is conducted. Once just-in-time activities are under way, they must continue indefinitely. The environment should be converted to one of constant improvement, and synergistic management and labor undertaking.
2. A clear recognition and working knowledge of just-in-time: this often calls for a model of the philosophy, with a component relationship that supports an understanding of their sequence and structure. A continual task is made to implement required operations with fewer resources (time, personnel and equipment) and in a less complex fashion.
3. Willingness to change: some manufacturing organizations have prematurely launched lead projects with known results. In many cases,

disinclined middle management, who had done business in the same way over the years, proved unwilling to give up activities that had previously proved successful.

4. Management commitment at every level: It is comparatively easy to get theatrical results rather quickly in improvement analysis. However, improvement efforts must continue, otherwise they will decline.

5. The benefits of synchronization and balance: this process includes the equating of throughput times from operation to operation during manufacturing and support functions, so all production occurs at a common rate.

Appendix C

Pilot Questionnaire

Operational Definition

For the purposes of this research Group Technology (GT) is defined as:

> "(1) The classification and coding of parts on the basis of similarity of parts. (2) The grouping of parts based on process similarities so that they can be processed together. (3) The grouping of various machines to produce a family of parts." (Institute of Industrial Engineering, 1989).

General Demographics

1. Annual sales $ _______________ (millions for 1994)

2. Total number of all employees _______________, and number of manufacturing personnel _______________

3. Total square feet of plant devoted to manufacturing ___________ (thousands of Sq. Ft.)

4. Number of different product produced _______________

5. Estimate percent of all parts manufactured %______ , and percent of all parts purchased %__________.

6. Estimate percent of all manufacturing activities or tasks devoted to:
   fabrication %__________, and to %__________ assembly

7. This is a: Unionized☐ Non-unionized Plant☐

8. Do you currently use group technology/cellular manufacturing systems:
   Yes☐ No ☐

9. If not, do you plan to implement group technology/cellular manufacturing system:
   Yes☐ No ☐

Strongly Agree = 1 Agree = 2 Neutral = 3 Disagree = 4 Strongly Disagree = 5

	1	2	3	4	5
Production Engineering Function					
10. GT improves man/machine utilization.	☐	☐	☐	☐	☐
11. A reduction in setting and machining times may be achieved by GT.	☐	☐	☐	☐	☐
12. Available floorspace may be increased by GT.	☐	☐	☐	☐	☐
13. GT provides an improved basis for future plant justification.	☐	☐	☐	☐	☐
14. Classification and coding reduce planning effort.	☐	☐	☐	☐	☐
15. A reduction in the number of planning may be achieved by GT.	☐	☐	☐	☐	☐
16. Companies may benefit from the use of standard planning as a result of GT.	☐	☐	☐	☐	☐
17. GT brings benefits from a decentralization.	☐	☐	☐	☐	☐
18. GT brings about a reduction in work handling indirect labor costs.	☐	☐	☐	☐	☐
19. Company's component range suggests a potential for GT.	☐	☐	☐	☐	☐
Design Engineering Function					
20. Duplication of component design effort may be avoided by use of classification and coding.	☐	☐	☐	☐	☐
21. Classification and coding improve drawing retrieval.	☐	☐	☐	☐	☐
22. GT presents opportunities for savings from exercises such as value analysis.	☐	☐	☐	☐	☐
23. GT encourages designing for production.	☐	☐	☐	☐	☐
24. The size of the drawing file may be decreased by introduction of classification and coding.	☐	☐	☐	☐	☐
25. Variety reduction and standardization may be achieved by use of classification and coding system.	☐	☐	☐	☐	☐
26. Classification and coding prevents duplication of design effort.	☐	☐	☐	☐	☐
Quality Engineering Function					
27. GT improves quality, reduce scrap and reduce rectification costs.	☐	☐	☐	☐	☐
28. The quality control effort may be reduced by the unification of responsibility, the delegation of inspection responsibility to direct labor and the development of specialized inspection techniques.	☐	☐	☐	☐	☐

Strongly Agree = 1 Agree = 2 Neutral = 3 Disagree = 4 Strongly Disagree = 5	1	2	3	4	5
Purchasing and Buying Function					
29. A reduction of material stock may be supported by improved supplier relations.	☐	☐	☐	☐	☐
30. GT leads to a reduction of subcontract work.	☐	☐	☐	☐	☐
Finance Function					
31. GT presents an opportunity for improving the costing system.	☐	☐	☐	☐	☐
32. GT offers opportunity for improving present incentive-scheme arrangement.	☐	☐	☐	☐	☐
Production Planning and Stock Control Function					
33. GT brings about a more effective production-control system.	☐	☐	☐	☐	☐
34. GT improves present production-planning procedures.	☐	☐	☐	☐	☐
35. GT reduces the stocktaking effort.	☐	☐	☐	☐	☐
36. GT leads to a reduction in raw material stock.	☐	☐	☐	☐	☐
37. GT leads to a reduction in finished-parts stock.	☐	☐	☐	☐	☐
38. GT leads to a reduction in work in progress.	☐	☐	☐	☐	☐
39. GT reduces progress-chasing staff.	☐	☐	☐	☐	☐
40. GT improves discipline and control within stock room.	☐	☐	☐	☐	☐
Direct Labor Function					
41. GT provides opportunity for improving labor relations from considerations such as working conditions, job satisfaction & remuneration.	☐	☐	☐	☐	☐
42. Problems are likely to be met in terms of homogeneity of skills and social compatibility in the formation of GT cells.	☐	☐	☐	☐	☐
43. GT improves absenteeism and turn-over.	☐	☐	☐	☐	☐
44. GT is likely to cause difficult-negotiations with trade unions.	☐	☐	☐	☐	☐
Marketing and Sales Function					
45. GT improves the competitive ability of the company by reducing cost, reducing sales prices or increasing profit margins.	☐	☐	☐	☐	☐
46. GT offers a mean of improving delivery performance in terms of reduced delivery periods and punctuality.	☐	☐	☐	☐	☐

Strongly Agree = 1 Agree = 2 Neutral = 3 Disagree = 4 Strongly Disagree = 5

	1	2	3	4	5
47. GT provides information of accurate costs of spares and special units which could lead to a rationalization of the product range.	☐	☐	☐	☐	☐
Management Function					
48. GT brings benefits from a unification of responsibility at first-line management.	☐	☐	☐	☐	☐
49. GT provides a basis for more effective company operation founded upon integrated systems.	☐	☐	☐	☐	☐
50. GT provides a mean of improving the definition of management responsibility and a more effective management structure.	☐	☐	☐	☐	☐
51. If a case were sufficiently proved, the implementation of GT will have the full support of top level management, particularly at top level.	☐	☐	☐	☐	☐
52. The company is sufficiently acquainted with innovation to be able to cope with the change of established method and procedure.	☐	☐	☐	☐	☐
53. There are many different approaches to implementation. Please indicate your opinion in regard to the following methods:	☐	☐	☐	☐	☐
A. A family of similar parts should first be identified without consulting existing routing.	☐	☐	☐	☐	☐
B. A key machine should be selected to serve as the nucleus of a cell. Then other machines can be added to the cell.	☐	☐	☐	☐	☐
C. A matrix showing the machines required by each part should be reordered to simultaneously identify groups of machines which process the same set of parts.	☐	☐	☐	☐	☐
D. Machine routings should first be examined to find parts which are processed on the same set of machines or to find *groups of machines which process* the same set of parts.	☐	☐	☐	☐	☐

**An assessment of Group Technology, and
Cellular Manufacturing System
in the Food Equipment and Preparation Manufacturing
in the United States and Canada**

I would like to take this opportunity to thank you for your assistance. As an appreciation for your cooperation it would be my pleasure to send you a summary of the results upon completion of this research. If you would like a copy of this summary, please complete the following section, cut at the dotted line and send it with your response to the questionnaire.

Full Name: ______________________________

Full Title (Optional): ______________________________

Company Name: ______________________________

Address: ______________________________
____

Telephone: ______________________________

Appendix D

Pilot Questionnaire, Participants' Comments

The pilot questionnaire was mailed out on December 9, 1994 to a total of 32 individuals selected through a stratified sampling technique. They were asked to comment on:

1. the clarity of questionnaire items,
2. whether various functional areas and adequate coverage, and
3. if any item should be deleted from or be added to this questionnaire.

The participants were asked not to answer any of the questions at this time and return their comments by December 16, 1994.

By December 21, 1994, only 15 (46.8%) had responded. A telephone follow up was made on December 22, 1994, to those who had not responded. This resulted in an additional 5 (15.6%) responses. On January 5, 1995, another telephone follow up was made to the remaining members who had not yet responded. This second telephone follow up, produced additional 2 (6.2%) responses. By January 13, 1995, a total of 23 (71.8%) had responded.

Based on an analysis of the comments received, the validity of the questionnaire with minor editorial or article modifications, was affirmed. These included such items as:

Statement 6: it was noted once, that the Statement should include machining operations as well as the fabrication and assembly.

Statement 11: it was noted by six of the participants, that the Statement should read as 'A reduction in setup and machining times may be achieved by GT'.

Statement 15: it was noted seven times, that the Statement was not clear and perhaps could read as 'GT facilitates the use of standard planning'.

Statement 18: it was noted once, that the Statement should read as 'GT reduces indirect costs due to less work handling'.

Statement 24: it was noted twice, that the Statement should be clarified such as 'Number of drawings may be reduced by introduction of classification and coding'.

Statement 27: it was noted three times, that the Statement should be reworded as 'GT improves quality, reduces scrap, and reduces rework costs'.

Statement 29: it was noted twice, that it would be better understood if the Statement read 'GT reduces the amount of outsourced work'.

Statement 32: it was noted twice, that the Statement should be clarified such as 'GT offers opportunity for improving present incentive based pay arrangement'.

Statement 35: it was noted once, that the Statement should read as 'GT reduces the inventory taking efforts'.

Statement 39: it was noted once, that the 'progress-chasing' was not clear and should read as 'GT reduces in process tracking or check points for inventory control'.

Statement 41: it was noted once, that the Statement should read as 'GT provides opportunity for improving labor relations by improving working conditions, job satisfaction, and remuneration'.

Statement 43: it was noted once, that the Statement should read as 'GT reduces absenteeism and turnover'.

Statement 47: it was noted once, that the Statement should be broken into two Statement so that it will be better understood.

Statement 51: it was noted four times, that the 'particularly at top level' was redundant and should be deleted and the statement should read as 'If a case were sufficiently proved, the implementation of GT will have the support of top level management'.

Lastly, a total of seven of the participants had indicated that none of the items required any modification and that various areas had adequate coverage.

Appendix E

Questionnaire, First Mailing

April 14, 1995

Dear Sir/Madam:

The Aston Business School, of Aston University, is carrying out a questionnaire survey of Food Equipment Preparation Manufacturing Organization in the United States and Canada. This study is being conducted to establish perceptions of the technical and non-technical administrators about Group Technology (GT).

We are especially interested in acquiring your responses, whether your organization uses GT or not and regardless of your functional area, because of your experience in the manufacturing area that will contribute significantly towards resolving some of the existing problems with group technology.

Please take a few minutes to complete the enclosed questionnaire and return it by Monday, May 1, 1995, in the prepaid envelope provided. This will be necessary to allow for the other phases of this research to be carried out. You can be assured that confidentiality will be maintained and no information will be released that could identify you or your organization.

We will be pleased to send you a summary of the survey results and hope that it will be an acceptable contribution in return of your valuable time. To maintain confidentiality, we would like to ask that you send a request indicating your full name and mailing address under separate cover.

Again, please accept our sincere thanks in advance and hope that you would be able to respond by Monday, May 1, 1995.

Sincerely Yours,

Dr. David Bennett
Advisor and Department Head
Technology & Innovation Research Program

H. Y. Eydgahi
Ph.D. Candidate

WE WOULD LIKE TO ASK THAT
YOU PROVIDE YOUR RESPONSE TO ALL QUESTIONS AND
STATEMENT, WHETHER YOUR ORGANIZATION USES GROUP
TECHNOLOGY OR NOT AND REGARDLESS OF YOUR FUNCTIONAL AREA

For purposes of this research, please note the following:

A. Operational Definitions

The following definitions are used in this research:

Group Technology (GT): GT is defined as the classification and coding of parts on the basis of similarity of parts, the grouping of parts based on process similarities so that they can be processed together or the grouping of various machines to produce a family of parts.

Classification and Coding: Classification and coding is defined as combining the individual items into classes according to their similarities and the assignment of symbols to classes, where symbols convey information about the particular class.

B. Questionnaire

The questionnaire is mainly divided into two parts. These are:

1. The first part contains statement about GT that requires your response by choosing one of the five possible answers. These are rated from 1 to 5 (1=Strongly Agree, 2=Agree, 3=Neutral, 4=Disagree, and 5=Strongly Disagree). Please note that, the division of the functional area in this part is only for ease of reading and we ask that you respond to ALL statement regardless of your functional area.

2. The second part, demographic section, is a more general section and applies to the entire organization and NOT individual plants, divisions, or departments. We ask that you provide exact answers. However, where actual data may not be known, we ask that you provide your best estimated answer.

Mail Survey Questionnaire

Strongly Agree = 1 Agree = 2 Neutral = 3 Disagree = 4 Strongly Disagree = 5

	1	2	3	4	5
Production Engineering Function					
1. GT improves machine utilization.	☐	☐	☐	☐	☐
2. GT improves labor utilization.	☐	☐	☐	☐	☐
3. A reduction in setting and machining times will be achieved by GT.	☐	☐	☐	☐	☐
4. Floor space requirements will be reduced by GT.	☐	☐	☐	☐	☐
5. GT provides a basis for determining future capital equipment and plant investment.	☐	☐	☐	☐	☐
6. Classification and coding reduce planning effort.	☐	☐	☐	☐	☐
7. Due to variety reduction and the use of standard planning, the number of planning will be reduced by GT.	☐	☐	☐	☐	☐
8. Companies will benefit from the use of standard planning as a result of GT.	☐	☐	☐	☐	☐
9. GT brings benefits from devolution and decentralization.	☐	☐	☐	☐	☐
10. GT reduces indirect costs due to less work handling.	☐	☐	☐	☐	☐
11. The company's component range suggests a potential for GT.	☐	☐	☐	☐	☐
12. If GT is not currently used, its potential benefits can be identified from company product range.	☐	☐	☐	☐	☐
Design Engineering Function					
13. Duplication of component design effort will be avoided by use of classification and coding.	☐	☐	☐	☐	☐
14. Classification and coding improves design detail retrieval.	☐	☐	☐	☐	☐
15. GT presents opportunities for savings from exercises such as value analysis.	☐	☐	☐	☐	☐
16. GT encourages designing for production.	☐	☐	☐	☐	☐
17. The number of drawings will be reduced by introduction of classification and coding.	☐	☐	☐	☐	☐
18. Classification and coding prevents duplication of design effort.	☐	☐	☐	☐	☐

Strongly Agree = 1 Agree = 2 Neutral = 3 Disagree = 4 Strongly Disagree = 5

	1	2	3	4	5
19. Variety reduction and standardization will be achieved by use of classification and coding.	☐	☐	☐	☐	☐
Quality Engineering Function					
20. GT improves quality, reduces scrap and reduces rework costs.	☐	☐	☐	☐	☐
21. The quality control effort will be reduced by the unification of responsibility and the delegation of inspection responsibilities to operator.	☐	☐	☐	☐	☐
22. The quality control effort will be reduced by the development of common inspection techniques.	☐	☐	☐	☐	☐
Purchasing and Buying Function					
23. GT will improve supplier relations.	☐	☐	☐	☐	☐
24. GT reduces the amount of outsourced work.	☐	☐	☐	☐	☐
Finance Function					
25. GT presents an opportunity for improving the costing system.	☐	☐	☐	☐	☐
26. GT offers an opportunity for improving the present incentive based pay arrangement.	☐	☐	☐	☐	☐
Production Planning and Stock Control Function					
27. GT brings about a more effective production-control system.	☐	☐	☐	☐	☐
28. GT improves present production-planning procedures.	☐	☐	☐	☐	☐
29. GT reduces the inventory taking effort.	☐	☐	☐	☐	☐
30. GT leads to a reduction in raw material stock.	☐	☐	☐	☐	☐
31. GT leads to a reduction in finished-parts stock.	☐	☐	☐	☐	☐
32. GT leads to a reduction in work in progress.	☐	☐	☐	☐	☐
33. GT reduces progress-chasing and expediting efforts.	☐	☐	☐	☐	☐
34. GT improves discipline and control within the stock room.	☐	☐	☐	☐	☐
Direct Labor Function					
35. GT provides an opportunity for improving labor relations by improving working conditions, job satisfaction and remuneration.	☐	☐	☐	☐	☐

Strongly Agree = 1 Agree = 2 Neutral = 3 Disagree = 4 Strongly Disagree = 5	1	2	3	4	5
36. Problems are likely to be met with homogeneity and range of skills and social compatibility in the formation of GT cells.	☐	☐	☐	☐	☐
37. GT reduces absenteeism and labor turn-over.	☐	☐	☐	☐	☐
38. GT is difficult to implement due to trade union resistance.	☐	☐	☐	☐	☐
Marketing and Sales Function					
39. GT improves the competitive ability of the company by reducing cost, and thereby, reducing sales prices or increasing profit margins.	☐	☐	☐	☐	☐
40. GT offers a means of improving delivery performance in terms of reduced delivery lead time and better punctuality.	☐	☐	☐	☐	☐
41. GT provides information to enable product range to be rationalized.	☐	☐	☐	☐	☐
Management Function					
42. GT brings benefits from a unification of responsibility at first-line management.	☐	☐	☐	☐	☐
43. GT provides a basis for more effective integrated systems within company operation.	☐	☐	☐	☐	☐
44. GT provides a means of more clearly defining management responsibilities.	☐	☐	☐	☐	☐
45. GT provides a means of creating a more effective management structure.	☐	☐	☐	☐	☐
46. If a case were sufficiently proved, the implementation of GT would have the full support of top level management.	☐	☐	☐	☐	☐
47. There are many different approaches to implementation. Please indicate your opinion with regard to the following methods:					
A. A family of similar parts should first be identified without reference to existing routings.	☐	☐	☐	☐	☐
B. A key machine should be selected to serve as the nucleus of a cell, then other machines can be added.	☐	☐	☐	☐	☐

Strongly Agree = 1 Agree = 2 Neutral = 3 Disagree = 4 Strongly Disagree = 5

	1	2	3	4	5
C. A matrix showing the machines required by each part should be reordered to simultaneously identify groups of machines which process the same set of parts.	☐	☐	☐	☐	☐
D. Machine routings should first be examined to find parts which are processed on the same set of machines or to find groups of machines which process the same set of parts.	☐	☐	☐	☐	☐

General Demographics
(the following questions apply to the entire organization and not the individual plants, divisions or departments)

48. Annual corporate sales $ _________ (millions for 1994).

49. Total number of all employees _________ , and number of manufacturing personnel _________.

50. Total square feet of plant devoted to manufacturing _________ (thousands of Sq. Ft.).

51. Number of different products produced _________ .

52. Estimate percent of all parts manufactured %_____ , and percent of all parts purchased %_____ .

53. Estimate percent of all manufacturing activities or tasks devoted to component manufacturing including machining & fabrication %_____ and %_____ to sub- and final assembly.

54. This is a: Unionized _____ Non-unionized Plant _____

55. Do you currently use group technology manufacturing system: Yes _____ No _____

56. If not, do you plan to implement group technology manufacturing system: Yes _____ No _____

57. Company structures are sufficiently flexible to be able to cope with introduction of GT: Yes ______ No ______

Appendix E

Questionnaire, Second Mailing

May 15, 1995

Dear Sir/Madam:

The Aston Business School, of Aston University, is carrying out a questionnaire survey of Food Equipment Preparation Manufacturing Organization in the United States and Canada. This study is being conducted to establish perceptions of the technical and non-technical administrators about Group Technology (GT).

We are especially interested in acquiring your responses, whether your organization uses GT or not and regardless of your functional area, because of your experience in the manufacturing area that will contribute significantly towards resolving some of the existing problems with group technology.

The first questionnaire was mailed on Friday, April 14, requesting your response by Monday, May 1, 1995. However, since we have not received your response, we believe that it may have been lost in the mail or misdirected. Therefore, enclosed questionnaire is being send to you again.

Please take a few minutes to complete the enclosed questionnaire and return it by Monday, June 5, 1995, in the prepaid envelope provided. This will be necessary to allow for the other phases of this research to be carried out. You can be assured that confidentiality will be maintained and no information will be released that could identify you or your organization.

We will be pleased to send you a summary of the survey results and hope that it will be an acceptable contribution in return of your valuable time. To maintain confidentiality, we would like to ask that you send a request indicating your full name and mailing address under separate cover.

Again, please accept our sincere thanks in advance and hope that you would be able to respond by Monday, June 5, 1995.

Sincerely Yours,

Dr. David Bennett
Advisor and Department Head
Technology & Innovation Research Program

H. Y. Eydgahi
Ph.D. Candidate

WE WOULD LIKE TO ASK THAT
YOU PROVIDE YOUR RESPONSE TO ALL QUESTIONS AND
STATEMENT, WHETHER YOUR ORGANIZATION USES GROUP
TECHNOLOGY OR NOT AND REGARDLESS OF YOUR FUNCTIONAL AREA

For purposes of this research, please note the following:

A. Operational Definitions

The following definitions are used in this research:

Group Technology (GT): GT is defined as the classification and coding of parts on the basis of similarity of parts, the grouping of parts based on process similarities so that they can be processed together or the grouping of various machines to produce a family of parts.

Classification and Coding: Classification and coding is defined as combining the individual items into classes according to their similarities and the assignment of symbols to classes, where symbols convey information about the particular class.

B. Questionnaire

The questionnaire is mainly divided into two parts. These are:

1. The first part contains statement about GT that requires your response by choosing one of the five possible answers. These are rated from 1 to 5 (1=Strongly Agree, 2=Agree, 3=Neutral, 4=Disagree, and 5=Strongly Disagree). Please note that, the division of the functional area in this part is only for ease of reading and we ask that you respond to ALL statement regardless of your functional area.

2. The second part, demographic section, is a more general section and applies to the entire organization and NOT individual plants, divisions, or departments. We ask that you provide exact answers. However, where actual data may not be known, we ask that you provide your best estimated answer.

Mail Survey Questionnaire

Strongly Agree = 1 Agree = 2 Neutral = 3 Disagree = 4 Strongly Disagree = 5

	1	2	3	4	5
Production Engineering Function					
1. GT improves machine utilization.	☐	☐	☐	☐	☐
2. GT improves labor utilization.	☐	☐	☐	☐	☐
3. A reduction in setting and machining times will be achieved by GT.	☐	☐	☐	☐	☐
4. Floor space requirements will be reduced by GT.	☐	☐	☐	☐	☐
5. GT provides a basis for determining future capital equipment and plant investment.	☐	☐	☐	☐	☐
6. Classification and coding reduce planning effort.	☐	☐	☐	☐	☐
7. Due to variety reduction and the use of standard planning, the number of planning will be reduced by GT.	☐	☐	☐	☐	☐
8. Companies will benefit from the use of standard planning as a result of GT.	☐	☐	☐	☐	☐
9. GT brings benefits from devolution and decentralization.	☐	☐	☐	☐	☐
10. GT reduces indirect costs due to less work handling.	☐	☐	☐	☐	☐
11. The company's component range suggests a potential for GT.	☐	☐	☐	☐	☐
12. If GT is not currently used, its potential benefits can be identified from company product range.	☐	☐	☐	☐	☐
Design Engineering Function					
13. Duplication of component design effort will be avoided by use of classification and coding.	☐	☐	☐	☐	☐
14. Classification and coding improves design detail retrieval.	☐	☐	☐	☐	☐
15. GT presents opportunities for savings from exercises such as value analysis.	☐	☐	☐	☐	☐
16. GT encourages designing for production.	☐	☐	☐	☐	☐
17. The number of drawings will be reduced by introduction of classification and coding.	☐	☐	☐	☐	☐
18. Classification and coding prevents duplication of design effort.	☐	☐	☐	☐	☐

Strongly Agree = 1 Agree = 2 Neutral = 3 Disagree = 4 Strongly Disagree = 5

	1	2	3	4	5
19. Variety reduction and standardization will be achieved by use of classification and coding.	☐	☐	☐	☐	☐

Quality Engineering Function

	1	2	3	4	5
20. GT improves quality, reduces scrap and reduces rework costs.	☐	☐	☐	☐	☐
21. The quality control effort will be reduced by the unification of responsibility and the delegation of inspection responsibilities to operator.	☐	☐	☐	☐	☐
22. The quality control effort will be reduced by the development of common inspection techniques.	☐	☐	☐	☐	☐

Purchasing and Buying Function ·

	1	2	3	4	5
23. GT will improve supplier relations.	☐	☐	☐	☐	☐
24. GT reduces the amount of outsourced work.	☐	☐	☐	☐	☐

Finance Function

	1	2	3	4	5
25. GT presents an opportunity for improving the costing system.	☐	☐	☐	☐	☐
26. GT offers an opportunity for improving the present incentive based pay arrangement.	☐	☐	☐	☐	☐

Production Planning and Stock Control Function

	1	2	3	4	5
27. GT brings about a more effective production-control system.	☐	☐	☐	☐	☐
28. GT improves present production-planning procedures.	☐	☐	☐	☐	☐
29. GT reduces the inventory taking effort.	☐	☐	☐	☐	☐
30. GT leads to a reduction in raw material stock.	☐	☐	☐	☐	☐
31. GT leads to a reduction in finished-parts stock.	☐	☐	☐	☐	☐
32. GT leads to a reduction in work in progress.	☐	☐	☐	☐	☐
33. GT reduces progress-chasing and expediting efforts.	☐	☐	☐	☐	☐
34. GT improves discipline and control within the stock room.	☐	☐	☐	☐	☐

Direct Labor Function

	1	2	3	4	5
35. GT provides an opportunity for improving labor relations by improving working conditions, job satisfaction and remuneration.	☐	☐	☐	☐	☐

Strongly Agree = 1 Agree = 2 Neutral = 3 Disagree = 4 Strongly Disagree = 5

	1	2	3	4	5
36. Problems are likely to be met with homogeneity and range of skills and social compatibility in the formation of GT cells.	☐	☐	☐	☐	☐
37. GT reduces absenteeism and labor turn-over.	☐	☐	☐	☐	☐
38. GT is difficult to implement due to trade union resistance.	☐	☐	☐	☐	☐
Marketing and Sales Function					
39. GT improves the competitive ability of the company by reducing cost, and thereby, reducing sales prices or increasing profit margins.	☐	☐	☐	☐	☐
40. GT offers a means of improving delivery performance in terms of reduced delivery lead time and better punctuality.	☐	☐	☐	☐	☐
41. GT provides information to enable product range to be rationalized.	☐	☐	☐	☐	☐
Management Function					
42. GT brings benefits from a unification of responsibility at first-line management.	☐	☐	☐	☐	☐
43. GT provides a basis for more effective integrated systems within company operation.	☐	☐	☐	☐	☐
44. GT provides a means of more clearly defining management responsibilities.	☐	☐	☐	☐	☐
45. GT provides a means of creating a more effective management structure.	☐	☐	☐	☐	☐
46. If a case were sufficiently proved, the implementation of GT would have the full support of top level management.	☐	☐	☐	☐	☐
47. There are many different approaches to implementation. Please indicate your opinion with regard to the following methods:					
A. A family of similar parts should first be identified without reference to existing routings.	☐	☐	☐	☐	☐
B. A key machine should be selected to serve as the nucleus of a cell, then other machines can be added.	☐	☐	☐	☐	☐

Strongly Agree = 1 Agree = 2 Neutral = 3 Disagree = 4 Strongly Disagree = 5

	1	2	3	4	5
C. A matrix showing the machines required by each part should be reordered to simultaneously identify groups of machines which process the same set of parts.	☐	☐	☐	☐	☐
D. Machine routings should first be examined to find parts which are processed on the same set of machines or to find groups of machines which process the same set of parts.	☐	☐	☐	☐	☐

General Demographics
(the following questions apply to the entire organization and not the individual plants, divisions or departments)

48. Annual corporate sales $ _________ (millions for 1994).

49. Total number of all employees _________ , and number of manufacturing personnel _________.

50. Total square feet of plant devoted to manufacturing _________ (thousands of Sq. Ft.).

51. Number of different products produced _________ .

52. Estimate percent of all parts manufactured %_____ , and percent of all parts purchased %_____ .

53. Estimate percent of all manufacturing activities or tasks devoted to component manufacturing including machining & fabrication %_____ and %_____ to sub- and final assembly.

54. This is a: Unionized _____ Non-unionized Plant _____

55. Do you currently use group technology manufacturing system: Yes _____ No _____

56. If not, do you plan to implement group technology manufacturing system: Yes _____ No _____

57. Company structures are sufficiently flexible to be able to cope with introduction of GT: Yes _______ No _______

Appendix F
General Linear Model Procedure
Repeated Measures Analysis of Variance
Technical vs Non-technical Group

Questionnaire Item	Type III SS	Mean Square	F Value	Pr>F
1. GT improves machine utilization.	42.25000000	42.25000000	58.87	0.0001
2. GT improves labor utilization.	42.25000000	42.25000000	65.49	0.0001
3. A reduction in setting and machining time will be achieved by GT.	41.44140625	41.44140625	71.64	0.0001
4. Floor space requirements will be reduced by GT.	42.25000000	42.25000000	52.39	0.0001
5. GT provides a basis for determining future capital equipment and plant investment.	33.78515625	33.78515625	66.12	0.0001
6. Classification and coding reduce planning effort.	21.97265625	21.97265625	57.23	0.0001
7. Due to variety reduction and the use of standard plannings, the number of plannings will be reduced by GT.	33.78515625	33.78515625	74.33	0.0001

Appendix F
General Linear Model Procedure
Repeated Measures Analysis of Variance
Technical vs Non-technical Group
(continued)

Questionnaire Item	Type III SS	Mean Square	F Value	Pr>F
8. Companies will benefit from the use of standard planning as a result of GT.	39.06250000	39.06250000	59.25	0.0001
9. GT brings benefits from devolution and decentralization.	33.78515625	33.78515625	59.54	0.0001
10. GT reduces indirect cost due to less work handling.	48.12890625	48.12890625	53.29	0.0001
11. The company's component range suggests a potential for GT.	38.28515625	38.28515625	40.11	0.0001
12. If GT is not currently used, its potential benefits can be identified from company product range.	43.89062500	43.89062500	45.57	0.0001
13. Duplication of component design effort will be avoided by use of classification and coding.	36.75390625	36.75390625	46.28	0.0001

Appendix F
General Linear Model Procedure
Repeated Measures Analysis of Variance
Technical vs Non-technical Group
(continued)

Questionnaire Item	Type III SS	Mean Square	F Value	Pr>F
14. Classification and coding improves design detail retrieval.	49.00000000	49.00000000	66.04	0.0001
15. GT presents opportunities for saving from exercises such as value analysis.	43.06640625	43.06640625	64.94	0.0001
16. GT encourages designing for production.	45.56250000	45.56250000	74.58	0.0001
17. The number of drawings will be reduced by introduction of classification and coding.	42.25000000	42.25000000	80.60	0.0001
18. Classification and coding prevents duplication of design effort.	33.06250000	33.06250000	47.81	0.0001
19. Variety reduction and standardization will be achieved by use of classification and coding.	32.34765625	32.34765625	50.70	0.0001

Appendix F
General Linear Model Procedure
Repeated Measures Analysis of Variance
Technical vs Non-technical Group
(continued)

Questionnaire Item	Type III SS	Mean Square	F Value	Pr>F
20. GT improves quality, reduces scrap and reduces rework costs.	55.31640625	55.31640625	74.37	0.0001
21. The quality control effort will be reduced by the unification of responsibility and the delegation of inspection responsibilities to operator.	39.06250000	39.06250000	48.56	0.0001
22. The quality control effort will be reduced by the development of common inspection techniques.	43.06640625	43.06640625	58.53	0.0001
23. GT will improve supplier relations.	36.00000000	36.00000000	44.64	0.0001
24. GT reduces the amount of outsourced work.	27.56250000	27.56250000	33.59	0.0001
25. GT presents an opportunity for improving the costing system.	39.06250000	39.06250000	53.37	0.0001

Appendix F
General Linear Model Procedure
Repeated Measures Analysis of Variance
Technical vs Non-technical Group
(continued)

Questionnaire Item	Type III SS	Mean Square	F Value	Pr>F
26. GT offers an opportunity for improving the present incentive based pay arrangement.	34.51562500	34.51562500	73.87	0.0001
27. GT brings about a more effective production-control system.	52.56250000	52.56250000	103.87	0.0001
28. GT improves present production-planning procedures.	55.31640625	55.31640625	97.66	0.0001
29. GT reduces the inventory taking effort.	49.00000000	49.00000000	86.80	0.0001
30. GT leads to a reduction in raw material stock.	42.25000000	42.25000000	62.37	0.0001
31. GT leads to a reduction in finished-parts stock.	36.75390625	36.75390625	60.38	0.0001

Appendix F
General Linear Model Procedure
Repeated Measures Analysis of Variance
Technical vs Non-technical Group
(continued)

Questionnaire Item	Type III SS	Mean Square	F Value	Pr>F
32. GT leads to a reduction in work in progress.	42.25000000	42.25000000	57.57	0.0001
33. GT reduces progress-chasing and expediting efforts.	46.41015625	46.41015625	80.09	0.0001
34. GT improves discipline and control within the stock room.	42.25000000	42.25000000	63.12	0.0001
35. GT provides an opportunity for improving labor relations by improving working conditions, job satisfaction and remuneration.	37.51562500	37.51562500	64.67	0.0001
36. Problems are likely to be met with homogeneity and range of skills and social compatibility in the formation of GT cells.	34.51562500	34.51562500	61.20	0.0001

Appendix F
General Linear Model Procedure
Repeated Measures Analysis of Variance
Technical vs Non-technical Group
(continued)

Questionnaire Item	Type III SS	Mean Square	F Value	Pr>F
37. GT reduces absenteeism and labor turn-over.	28.89062500	28.89062500	57.38	0.0001
38. GT is difficult to implement due to trade union resistance.	10.16015625	10.16015625	19.13	0.0001
39. GT improves the competitive ability of the company by reducing cost, and thereby, reducing sales prices or increasing profit margins.	47.26562500	47.26562500	65.17	0.0001
40. GT offers a mean of improving delivery performance in terms of reduced delivery lead time and better punctuality.	46.41015625	46.41015625	74.88	0.0001
41. GT provides information to enable product range to be rationalized.	39.06250000	39.06250000	81.07	0.0001

Appendix F
General Linear Model Procedure
Repeated Measures Analysis of Variance
Technical vs Non-technical Group
(continued)

Questionnaire Item	Type III SS	Mean Square	F Value	Pr>F
42. GT brings benefits from a unification of responsibility at first-line management.	48.12890625	48.12890625	85.28	0.0001
43. GT provides a basis for more effective integrated systems within company operation.	42.25000000	42.25000000	66.32	0.0001
44. GT provides a means of more clearly defining management responsibilities.	48.12890625	48.12890625	93.27	0.0001
45. GT provides a means of creating a more effective management structure.	36.75390625	36.75390625	86.84	0.0001
46. If a case were sufficiently proved, the implementation of GT would have the full support of top level management.	37.51562500	37.51562500	43.91	0.0001

Appendix F
General Linear Model Procedure
Repeated Measures Analysis of Variance
Technical vs Non-technical Group
(continued)

Questionnaire Item	Type III SS	Mean Square	F Value	Pr>F
47. There are many different approaches to implementation. Please indicate your opinion with regards to the following methods:				
A. A family of similar parts should first be identified without reference to existing routings.	36.00000000	36.00000000	48.52	0.0001
B. A key machine should be selected to serve as the nucleus of a cell, then other machines can be added.	39.84765625	39.84765625	74.74	0.0001
C. A matrix showing the machines required by each part should be reordered to simultaneously identify groups of machines which process the same set of parts.	43.06640625	43.06640625	76.03	0.0001

Appendix F
General Linear Model Procedure
Repeated Measures Analysis of Variance
Technical vs Non-technical Group
(continued)

Questionnaire Item	Type III SS	Mean Square	F Value	Pr>F
D. Machine routings should first be examined to find parts which are processed on the same set of machines or to find groups of machines which process the same set of parts.	48.12890625	48.12890625	70.22	0.0001

Appendix F
General Linear Model Procedure
Repeated Measures Analysis of Variance
Summary of Means

Questionnaire Item	Type III SS	Mean Square	F Value	Pr>F
MT = Mean of MD - MM	0.01462662	0.01462662	0.04	0.8357
MN = Mean of MF - MK	0.06979892	0.06979892	0.11	0.7432
Mean of MT - MN	39.55513979	39.55513979	106.30	0.0001

MT = Mean of Technical Group, MD and MM
    MD = Mean of D1 - D50, Design Engineering Group
    MM = Mean of M1 - M50, Manufacturing and Production Engineering Group

MN = Mean of Non-technical Group, MF and MK
    MF = Mean of F1 - F50, Finance and Accounting Group
    MK = Mean of K1 - K50, Marketing and Sales Group

Appendix G
General Linear Model Procedure
Repeated Measures Analysis of Variance
Non-technical Group

Questionnaire Item	Type III SS	Mean Square	F Value	Pr>F
1. GT improves machine utilization.	0.00000000	0.00000000	0.00	1.0000
2. GT improves labor utilization.	0.04545455	0.04545455	0.02	0.9002
3. A reduction in setting and machining time will be achieved by GT.	0.40909091	0.40909091	0.21	0.6533
4. Floor space requirements will be reduced by GT.	0.18181818	0.18181818	0.31	0.5884
5. GT provides a basis for determining future capital equipment and plant investment.	0.72727273	0.72727273	0.65	0.4405
6. Classification and coding reduce planning effort.	0.18181818	0.18181818	0.17	0.6905
7. Due to variety reduction and the use of standard plannings, the number of plannings will be reduced by GT.	1.63636364	1.63636364	1.75	0.2156

Appendix G
General Linear Model Procedure
Repeated Measures Analysis of Variance
Non-technical Group
(continued)

Questionnaire Item	Type III SS	Mean Square	F Value	Pr>F
8. Companies will benefit from the use of standard planning as a result of GT.	0.72727273	0.72727273	0.78	0.3966
9. GT brings benefits from devolution and decentralization.	0.04545455	0.04545455	0.06	0.8100
10. GT reduces indirect cost due to less work handling.	0.40909091	0.40909091	0.45	0.5175
11. The company's component range suggests a potential for GT.	0.18181818	0.18181818	0.19	0.6761
12. If GT is not currently used, its potential benefits can be identified from company product range.	0.45000000	0.45000000	0.25	0.6275
13. Duplication of component design effort will be avoided by use of classification and coding.	0.04545455	0.04545455	0.05	0.8309

Appendix G
General Linear Model Procedure
Repeated Measures Analysis of Variance
Non-technical Group
(continued)

Questionnaire Item	Type III SS	Mean Square	F Value	Pr>F
14. Classification and coding improves design detail retrieval.	0.72727273	0.72727273	1.38	0.2674
15. GT presents opportunities for saving from exercises such as value analysis.	0.18181818	0.18181818	0.21	0.6595
16. GT encourages designing for production.	0.40909091	0.40909091	0.24	0.6352
17. The number of drawings will be reduced by introduction of classification and coding.	1.63636364	1.63636364	1.22	0.2944
18. Classification and coding prevents duplication of design effort.	0.18181818	0.18181818	0.13	0.7244
19. Variety reduction and standardization will be achieved by use of classification and coding.	2.90909091	2.90909091	2.22	0.1669

Appendix G
General Linear Model Procedure
Repeated Measures Analysis of Variance
Non-technical Group
(continued)

Questionnaire Item	Type III SS	Mean Square	F Value	Pr>F
20. GT improves quality, reduces scrap and reduces rework costs.	0.00000000	0.00000000	0.00	1.0000
21. The quality control effort will be reduced by the unification of responsibility and the delegation of inspection responsibilities to operator.	0.04545455	0.04545455	0.05	0.8309
22. The quality control effort will be reduced by the development of common inspection techniques.	0.40909091	0.40909091	0.34	0.5737
23. GT will improve supplier relations.	0.04545455	0.04545455	0.06	0.8100
24. GT reduces the amount of outsourced work.	0.18181818	0.18181818	0.27	0.6168
25. GT presents an opportunity for improving the costing system.	0.04545455	0.04545455	0.06	0.8100

Appendix G
General Linear Model Procedure
Repeated Measures Analysis of Variance
Non-technical Group
(continued)

Questionnaire Item	Type III SS	Mean Square	F Value	Pr>F
26. GT offers an opportunity for improving the present incentive based pay arrangement.	0.04545455	0.04545455	0.06	0.8100
27. GT brings about a more effective production-control system.	0.18181818	0.18181818	0.21	0.6595
28. GT improves present production-planning procedures.	0.72727273	0.72727273	0.71	0.4198
29. GT reduces the inventory taking effort.	0.04545455	0.04545455	0.31	0.5884
30. GT leads to a reduction in raw material stock.	0.40909091	0.40909091	1.00	0.3409
31. GT leads to a reduction in finished-parts stock.	0.40909091	0.40909091	1.00	0.3409

Appendix G
General Linear Model Procedure
Repeated Measures Analysis of Variance
Non-technical Group
(continued)

Questionnaire Item	Type III SS	Mean Square	F Value	Pr>F
32. GT leads to a reduction in work in progress.	0.72727273	0.72727273	1.16	0.3069
33. GT reduces progress-chasing and expediting efforts.	0.04545455	0.4545455	0.08	0.7787
34. GT improves discipline and control within the stock room.	0.04545455	0.4545455	0.13	0.7244
35. GT provides an opportunity for improving labor relations by improving working conditions, job satisfaction and remuneration.	0.20000000	0.20000000	0.17	0.6926
36. Problems are likely to be met with homogeneity and range of skills and social compatibility in the formation of GT cells.	0.04545455	0.04545455	0.07	0.7961

Appendix G
General Linear Model Procedure
Repeated Measures Analysis of Variance
Non-technical Group
(continued)

Questionnaire Item	Type III SS	Mean Square	F Value	Pr>F
37. GT reduces absenteeism and labor turn-over.	0.72727273	0.72727273	1.00	0.3409
38. GT is difficult to implement due to trade union resistance.	0.04545455	0.04545455	0.06	0.8100
39. GT improves the competitive ability of the company by reducing cost, and thereby, reducing sales prices or increasing profit margins.	1.63636364	1.63636364	1.32	0.2767
40. GT offers a mean of improving delivery performance in terms of reduced delivery lead time and better punctuality.	1.63636364	1.63636364	1.44	0.2578
41. GT provides information to enable product range to be rationalized.	0.72727273	0.72727273	0.65	0.4405

Appendix G
General Linear Model Procedure
Repeated Measures Analysis of Variance
Non-technical Group
(continued)

Questionnaire Item	Type III SS	Mean Square	F Value	Pr>F
42. GT brings benefits from a unification of responsibility at first-line management.	0.04545455	0.04545455	0.05	0.8309
43. GT provides a basis for more effective integrated systems within company operation.	2.90909091	2.90909091	2.22	0.1669
44. GT provides a means of more clearly defining management responsibilities.	0.04545455	0.04545455	0.07	0.7961
45. GT provides a means of creating a more effective management structure.	0.18181818	0.18181818	0.31	0.5884
46. If a cue were sufficiently proved, the implementation of GT would have the full support of top level management.	0.18181818	0.18181818	0.31	0.5884

Appendix G
General Linear Model Procedure
Repeated Measures Analysis of Variance
Non-technical Group
(continued)

Questionnaire Item	Type III SS	Mean Square	F Value	Pr>F
47. There are many different approaches to implementation. Please indicate your opinion with regards to the following methods:				
A. A family of similar parts should first be identified without reference to existing routings.	1.13636364	1.13636364	1.00	0.3409
B. A key machine should be selected to serve as the nucleus of a cell, then other machines can be added.	1.13636364	1.1363634	0.85	0.3782
C. A matrix showing the machines required by each part should be reordered to simultaneously identify groups of machines which process the same set of parts.	2.22727273	2.22727273	1.81	0.2077

Appendix G
General Linear Model Procedure
Repeated Measures Analysis of Variance
Non-technical Group
(continued)

Questionnaire Item	Type III SS	Mean Square	F Value	Pr>F
D. Machine routings should first be examined to find parts which are processed on the same set of machines or to find groups of machines which process the same set of parts.	0.04545455	0.04545455	0.03	0.8578

Appendix H
General Linear Model Procedure
Repeated Measures Analysis of Variance
Technical Group

Questionnaire Item	Type III SS	Mean Square	F Value	Pr>F
1. GT improves machine utilization.	0.00000000	0.00000000	0.00	1.0000
2. GT improves labor utilization.	0.00000000	0.00000000	0.00	1.0000
3. A reduction in setting and machining time will be achieved by GT.	0.28571429	0.28571429	0.49	0.4895
4. Floor space requirements will be reduced by GT.	0.28571429	0.28571429	0.24	0.6259
5. GT provides a basis for determining future capital equipment and plant investment.	0.00000000	0.00000000	0.00	1.0000
6. Classification and coding reduce planning effort.	0.01785714	0.01785714	0.02	0.8894
7. Due to variety reduction and the use of standard plannings, the number of plannings will be reduced by GT.	0.01785714	0.1785714	0.02	0.8820

Appendix H
General Linear Model Procedure
Repeated Measures Analysis of Variance
Technical Group
(continued)

Questionnaire Item	Type III SS	Mean Square	F Value	Pr>F
8. Companies will benefit from the use of standard planning as a result of GT.	0.16071429	0.16071429	0.28	0.5992
9. GT brings benefits from devolution and decentralization.	0.28571429	0.28571429	0.44	0.5149
10. GT reduces indirect cost due to less work handling.	0.44642857	0.44642857	1.71	0.2022
11. The company's component range suggests a potential for GT.	0.64285714	0.64285714	0.85	0.3640
12. If GT is not currently used, its potential benefits can be identified from company product range.	1.14285714	1.14285714	1.95	0.1744
13. Duplication of component design effort will be avoided by use of classification and coding.	0.64285714	0.64285714	0.95	0.3395

Appendix H
General Linear Model Procedure
Repeated Measures Analysis of Variance
Technical Group
(continued)

Questionnaire Item	Type III SS	Mean Square	F Value	Pr>F
14. Classification and coding improves design detail retrieval.	0.07142857	0.07142857	0.09	0.7691
15. GT presents opportunities for saving from exercises such as value analysis.	0.16071429	0.16071429	0.38	0.5414
16. GT encourages designing for production.	0.00000000	0.00000000	0.00	1.0000
17. The number of drawings will be reduced by introduction of classification and coding.	0.87500000	0.87500000	0.70	0.4093
18. Classification and coding prevents duplication of design effort.	0.01785714	0.01785714	0.02	0.9024
19. Variety reduction and standardization will be achieved by use of classification and coding.	0.07142857	0.07142857	0.10	0.7520

Appendix H
General Linear Model Procedure
Repeated Measures Analysis of Variance
Technical Group
(continued)

Questionnaire Item	Type III SS	Mean Square	F Value	Pr>F
20. GT improves quality, reduces scrap and reduces rework costs.	0.64285714	0.64285714	0.71	0.4060
21. The quality control effort will be reduced by the unification of responsibility and the delegation of inspection responsibilities to operator.	0.07142857	0.07142857	0.11	0.7455
22. The quality control effort will be reduced by the development of common inspection techniques.	0.00000000	0.00000000	0.00	1.0000
23. GT will improve supplier relations.	0.44642857	0.44642857	1.71	0.2022
24. GT reduces the amount of outsourced work.	1.78571429	1.78571429	2.08	0.1610
25. GT presents an opportunity for improving the costing system.	0.00000000	0.00000000	0.00	1.0000

Appendix H
General Linear Model Procedure
Repeated Measures Analysis of Variance
Technical Group
(continued)

Questionnaire Item	Type III SS	Mean Square	F Value	Pr>F
26. GT offers an opportunity for improving the present incentive based pay arrangement.	0.07142857	0.07142857	0.09	0.7691
27. GT brings about a more effective production-control system.	0.01785714	0.01785714	0.02	0.8871
28. GT improves present production-planning procedures.	1.14285714	1.14285714	2.08	0.1610
29. GT reduces the inventory taking effort.	0.07142857	0.07142857	0.09	0.7638
30. GT leads to a reduction in raw material stock.	1.14285714	1.14285714	1.48	0.2344
31. GT leads to a reduction in finished-parts stock.	1.78571429	1.78571429	2.51	0.1248

Appendix H
General Linear Model Procedure
Repeated Measures Analysis of Variance
Technical Group
(continued)

Questionnaire Item	Type III SS	Mean Square	F Value	Pr>F
32. GT leads to a reduction in work in progress.	1.78571429	1.78571429	3.39	0.0765
33. GT reduces progress-chasing and expediting efforts.	0.87500000	0.87500000	0.96	0.3360
34. GT improves discipline and control within the stock room.	0.01785714	0.01785714	0.02	0.8792
35. GT provides an opportunity for improving labor relations by improving working conditions, job satisfaction and remuneration.	1.85185185	1.85185185	1.99	0.1698
36. Problems are likely to be met with homogeneity and range of skills and social compatibility in the formation of GT cells.	0.66666667	0.66666667	1.30	0.2646

Appendix H
General Linear Model Procedure
Repeated Measures Analysis of Variance
Technical Group
(continued)

Questionnaire Item	Type III SS	Mean Square	F Value	Pr>F
37. GT reduces absenteeism and labor turn-over.	3.62962963	3.6296293	4.63	0.0408
38. GT is difficult to implement due to trade union resistance.	0.16666667	0.1666667	0.27	0.6108
39. GT improves the competitive ability of the company by reducing cost, and thereby, reducing sales prices or increasing profit margins.	0.44642857	0.44642857	0.86	0.3626
40. GT offers a mean of improving delivery performance in terms of reduced delivery lead time and better punctuality.	1.14285714	1.14285714	2.84	0.1033
41. GT provides information to enable product range to be rationalized.	0.64285714	0.64285714	1.40	0.2463

Appendix H
General Linear Model Procedure
Repeated Measures Analysis of Variance
Technical Group
(continued)

Questionnaire Item	Type III SS	Mean Square	F Value	Pr>F
42. GT brings benefits from a unification of responsibility at first-line management.	0.00000000	0.00000000	0.00	1.0000
43. GT provides a basis for more effective integrated systems within company operation.	0.46285714	0.46285714	1.85	0.1845
44. GT provides a means of more clearly defining management responsibilities.	0.07142857	0.07142857	0.08	0.7830
45. GT provides a means of creating a more effective management structure.	0.64285714	0.64285714	0.74	0.3963
46. If a case were sufficiently proved, the implementation of GT would have the full support of top level management.	0.64285714	0.64285714	1.06	0.3121

Appendix H
General Linear Model Procedure
Repeated Measures Analysis of Variance
Technical Group
(continued)

Questionnaire Item	Type III SS	Mean Square	F Value	Pr>F
47. There are many different approaches to implementation. Please indicate your opinion with regards to the following methods:				
A. A family of similar parts should first be identified without reference to existing routings.	0.44642857	0.44642857	0.52	0.4758
B. A key machine should be selected to serve as the nucleus of a cell, then other machines can be added.	0.07142857	0.07142857	0.06	0.8015
C. A matrix showing the machines required by each part should be reordered to simultaneously identify groups of machines which process the same set of parts.	0.07407407	0.07407407	0.11	0.7386

Appendix H
General Linear Model Procedure
Repeated Measures Analysis of Variance
Technical Group
(continued)

Questionnaire Item	Type III SS	Mean Square	F Value	Pr>F
D. Machine routings should first be examined to find parts which are processed on the same set of machines or to find groups of machines which process the same set of parts.	0.29629630	0.29629630	0.72	0.4040

GLOSSARY

Within the framework of this research, the following definitions will be applied (Institute of Industrial Engineering, 1989):

Batch Manufacturing: "The production of parts in discrete runs, or batches. Batch operations can be interspersed with other production operations or runs of other parts." p. 17-3.

Batch Processing: "A manufacturing operation in which a designated quantity of material is treated in a series of steps. Also, a method of processing jobs so that each is completed before the next job is initiated." p. 17-3.

Cell: "Manufacturing unit consisting of a number of work stations and the materials - transport mechanism and storage buffers that interconnect them." p. 17-3.

Cellular Manufacturing: "Organization of manufacturing equipment into groups according to function and inter-machine relationship." p. 17-3.

Classification: "A systematic and orderly analysis of items, grouping like things together by their common features and subdividing them by their special features." p. 10-5.

Code: "A system of organized symbols representing information in a language that can be understood and handled by a control system. A system of symbols that can be used by machines such as computers. Special external meaning is dictated by the specific arrangement of the symbols." pp.7-6.

Cycle Time: "The period of time from starting one machine operation to starting another (in a pattern of continuous repetition)." p. 17-5.

Flexible Manufacturing System (FMS): "An integrated system of process machines, material handling, and computer control system." p. 17-6.

Group Technology:

"(1) The classification and coding of parts on the basis of similarity of parts,

(2) The grouping of parts based on process similarities so that they can be processed together, and

(3) The grouping of various machines to produce a family of parts." p. 7-12.

Just-in-Time (JIT): "A philosophy concerning the operation of the business that teaches only activities that add value to a product or services are beneficial; all other activities are viewed as waste. JIT is designed to reduce inventory and work in process by grouping machines and operations into work cells by product, rather than by similar machine grouping." p. 11-9.

Manufacturing Cell: "A grouping of equipment to form a self-contained autonomous unit to produce parts or products of similar geometry and specification; equipment may range from traditional machine tools through computer numerical control machines and robots." p. 11-11.

Manufacturing Cost: "The total of variable & fixed or direct and indirect cost chargeable to the production of a given product, usually expressed in cents or dollars per year. Transportation and distribution costs, and research, development, selling, and corporate administrative expenses are usually excluded." p. 13-14.

Process Quality: "A statistical measure for the quality of product from a given process." p. 8-20.

Quality Circle: "A technique used in Japanese companies and adopted by some American companies in which groups of workers, usually under guidance of a facilitator or trainer, seek to find ways to resolve quality problems, improve quality, and increase production. Can be used with both office and factory workers. Sometimes considered the first step in participative management." p. 13-45.

Work Cell: "A group of machines arranged to process a family of parts in a way that minimizes material handling and storage between operations; can handle a lot size of one piece, and integrated in such a way that the cell produces a finished product." p. 11-19.

Work-in-Process (WIP): "Product in various stages of completion throughout the plant including raw material that has been released for initial processing and completely processed material awaiting final inspection and acceptance as finish product. Many accounting systems also include semi-finished stock and components in this category." p. 10-21.